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DEMONSTRATION OF A PLANNING PERSPECTIVE FOR WASTE WATER SLUDGE DISPOSITION. OHIO/KENTUCKY/INDIANA

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PEDCo-Environmental Specialists,
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This study is an investigation of the wastewater treatment and sludge disposal methods of 18 plants in the Ohio-Kentucky-Indiana region as a means of testing an application of a methodology previously developed by the EPA. The plants selected for analys represent about 80% of the total treatment capacity of the region; individual plant capacities range from 35,000 to 120 million gpd (133 to 456,000 m^3/d).

In application of the methodology, various sludge management alternatives are analyzed in terms of technical feasibility, costs, environmental impacts, socio-political implications, and other factors pertinent to regional-scale planning. For each of the plants (15 now operating and 3 proposed) a case hsitory ~~is~~ is developed and suitable sludge disposal alternatives identified. In addition, four alrernatives are presented for region-wide sludge management systems.

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DEMONSTRATION OF A PLANNING PERSPECTIVE
FOR THE
ULTIMATE DISPOSAL OF RESIDUAL WASTES

OHIO/KENTUCKY/INDIANA

Project Officer
Dr. M. Dean Neptune

Contract No. 68-01-3503

U.S. ENVIRONMENTAL PROTECTION AGENCY
Water Planning Division
Planning Assistance and Policy Branch
Washington, D.C. 20460

January 1976

ABSTRACT

The U.S. Environmental Protection Agency has published a comprehensive methodology for planning of sludge management on a regional scale. As a means of testing application of the methodology in conjunction with an ongoing 208 planning project, PEDCo-Environmental Specialists, Inc. investigated the wastewater treatment and sludge disposal methods of 18 plants in the Ohio-Kentucky-Indiana (O-K-I) region. The plants selected for analysis represent about 80 percent of the total treatment capacity in the region; individual plant capacities range from 35,000 to 120 million gpd (133 to 456,000 m^3/d).

In application of the methodology, various sludge management alternatives are analyzed in terms of technical feasibility, costs, environmental impacts, socio-political implications, and other factors pertinent to regional-scale planning. For each of the plants (15 now operating and 3 proposed) a case history is developed and suitable sludge disposal alternatives identified. In addition, four alternatives are presented for region-wide sludge management systems.

This report is submitted in fulfillment of RFP No. WA-75-R217, Contract No. 68-01-3503, by PEDCo-Environmental Specialists, Inc. under sponsorship of the U.S. Environmental Protection Agency. Work was completed October 31, 1975.

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Direction of this project for PEDCo-Environmental Specialists, Inc. was conducted by Richard O. Toftner. Principal investigators were Messrs. Vijay Patel, Thomas Janszen and Charles Sawyer. Technical editing was performed by Ms. Anne Cassel; graphics were prepared under the direction of Mr. Charles Fleming.

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1.0 SUMMARY

The U.S. Environmental Protection Agency has published a comprehensive set of analytical procedures for use in the planning of residual waste management; the planning document is titled Sludge Processing, Transportation and Disposal/Resource Recovery: A Planning Perspective (Ref. I-1). The analytical procedures outlined in that document provide the basis of this study and are referred to hereinafter simply as "the methodology."

The purpose of this project is to demonstrate application of the methodology to a particular locale: the nine-county region encompassed by the Ohio, Kentucky, Indiana Regional Council of Governments, known as the O-K-I. The O-K-I Council undertakes responsibility for sludge management planning as a function of Section 208 of the Federal Water Pollution Control Act, amendments of 1972, which provides for an area-wide approach to water pollution control.

Demonstration of the methodology, as reported here, represents a preliminary analysis; it does not constitute a base for final selection among the many possible alternatives for residual waste disposal in the region.

Within the O-K-I region some 158 wastewater treatment facilities generate residual sludge for disposal; from among these, 15 operating facilities and 3 proposed facilities are selected for detailed evaluation. These 18 facilities represent approximately 80 percent of the total treatment capacity within the region. Flow capacities of these plants range from 35,000 gpd to 120 million gpd (133 to 456,000 m^3/d). Each of the 15 operating facilities has been issued a National Pollution Discharge Elimination System (NPDES) permit. Analysis of each facility is based on the following factors:

- Volumes of sludge generated.
- Characteristics of the sludge.
- Current sludge disposal methods.
- Recommended or future sludge disposal methods as a function of technical feasibility, economics, socio-political effects, land availability, and environmental impacts.

The analyses, presented in Section 8, indicate that except for the various disposal methods currently being practiced by each wastewater treatment plant (WTP), wet land spreading appears to be the most universally applicable sludge disposal method.

In addition, because facilities in the O-K-I region exhibit a variety of sludge-handling techniques that are amenable to consolidation, four regional scale approaches to sludge management are developed.

1. Sludge generated by the O-K-I wastewater treatment facilities could be transported to one of four centralized processing facilities or transfer stations equipped with sludge dewatering capabilities. Transport trucks would haul the dewatered sludge to a regionalized landfill site suitable to contain all the sludge processed from the O-K-I region. Such a site should be compatible with population centers and should represent favorable conditions with respect to soil, bedrock, groundwater, flora and fauna, and meteorology. Since the Mill Creek wastewater treatment plant already dewaters quantities of sludge comparable to those expected at a proposed transfer station, this plant could act as its own transfer station.

2. Again with the four centralized transfer stations, dewatered sludge could be consolidated at these points and then transported to a barge-loading facility near the Ohio River. Barges would carry the dewatered sludge down river for disposal in an approved reclamation site in Daviess County, Kentucky.

3. Dewatered sludge from the four centralized transfer stations could feasibly be land spread on designated agricultural or rural lands in the O-K-I region. One such area is located in Dearborn County, Indiana, where hydrology, topography, and soil associations appear suitable for land spreading without adverse effects.

4. Finally, dewatered sludge from the four centralized transfer stations could feasibly be incinerated at the Mill Creek wastewater treatment facility where sufficient incinerator capacity exists to handle the total daily production of dewatered sludge in the O-K-I region. The incinerator asn would be slurried and placed in lagoons located on-site at the facility. Periodically, the lagoons would be drained and the bottoms hauled away for landfill disposal.

To facilitate a regionalized system of sludge management, an areawide service agency could be formed to collect, transport, process, and dispose of sludge from all wastewater treatment plants on a prorated, user-charge basis. The agency could be public or private, or perhaps managed by the largest sewer district (therein the largest contributor of sludge) within the region.

With respect to application of the methodology in this project, the following are summary comments:

- The documentation of typical cost data for sludge transport and disposal by site specific wastewater treatment facilities in the O-K-I region does not exist. Cost data presented in the methodology itself were quite useful in developing first-order feasibility, bottomline costs necessary for comparative analysis of alternative sludge disposal methods.

- Within the O-K-I region, there exists little available information on industrial sludges and their impact upon municipal wastewater treatment facilities and subsequent disposal sites. No attempt was made in this report to assess the industrial sludge contribution upon these O-K-I facilities.

- The methodology is a valuable resource tool, useful particularly for its delineation of sludge management alternatives; its presentation of sludge processing techniques, such as thickening, stabilization, dewatering, and drying or reduction; and its detailed references encompassing major aspects of disposal/recovery.

- The methodology presents typical situations and provides patterns of analysis; these were adjusted and modified in application to the eighteen sample wastewater treatment facilities in the O-K-I region.

- The application of the methodology suggests that only slight advantage, resulting in excess costs, may occur in employing anaerobic digestion along with incineration. Therefore, it is recommended that future design and provision of facilities involve a more careful consideration for omitting one or the other process. Also, it may be possible to eliminate unnecessary processing in existing plants thus saving O&M costs.

As a result of this application of the methodology to wastewater treatment facilities in the O-K-I region, further recommendations are proposed:

- Analyses similar to those performed on sludges from the Franklin WTP (reported in Section 5) should be made on sludges from all facilities in the region. Such analyses would identify potential problems, such as presence of heavy metals, or other constraints on landfill or land spreading practices.

- Any centralized sludge transfer or disposal facility must satisfy current and future Federal, state, and local guidelines and standards for air and water quality.

REFERENCES

I-1 Wyatt, J.M., and P. E. White, Jr., Sludge Processing, Transportation, and Disposal/Resource Recovery: A planning Perspective. Engineering-Science, Inc. EPA Contract No. 68-01-3104. April 1975.

2.0 INTRODUCTION

Treatment of municipal and industrial wastewaters involves the generation of sludge. As Federal and local standards for water quality and waste treatment become more stringent, the quantities of sludge increase. It is estimated that the quantity of sludge generated by municipal wastewater treatment plants in the U.S. in 1974 is about 5.2 million tons (4.72 million metric tons) per year, on a dry basis (Ref. II-1).

Currently more than 21,000 publicly owned treatment plants are operating in the United States (Ref. II-2). Over 18,000 of these, or about 86 percent, handle relatively small volumes of wastewater - 1 mgd (3800 m^3/day) or less. Cost of these small-scale operations are significantly higher than the costs that would be incurred in operation of larger plants on a regional scale.

The high costs of current wastewater treatment and sludge disposal practices represent only one aspect of the problem; protection of the environment is another significant consideration. Many waste treatment plants now dispose of sludge by the lowest-cost methods possible, with little regard for potential environmental hazards or conservation of resources. Some examples found in the O-K-I area are: disposal at open municipal dumps, on flood plains without cover, and on farms without precautions for protection of livestock. Digested or semidigested sludge is often disposed of as if it were completely innocuous, even though well-digested sludge could contain pathogens, intestinal parasites, and other hazardous constituents. Similarly, industrial waste sludges are often disposed of without regard for their toxic constituents. The attenuating characteristics of soils at the disposal site or possible contamination of surface and groundwaters often are not considered.

Economic and environmental factors, therefore, must figure strongly in the planning of wastewater treatment and sludge management practices. Other major factors, too, can affect the decisions of planners; for example, they must consider the potential for recovery of resources, socio-political implications, and possible institutional and jurisdictional arrangements. Recognizing the need for in-depth analysis and orderly presentation of the many factors involved, the U.S. Environmental Protection Agency commissioned a study of currently available alternatives for sludge disposal, with the aim of developing guidelines for sludge management planning. In April 1975 EPA published the resultant planning document, titled Sludge Processing Transportation, and Disposal/Resource Recovery: A Planning Perspective (Ref. II-3). That document, referred to in this report as 'the methodology,' identifies the major planning considerations and provides techniques for decision-making and selection of optimum alternatives.

As a means of testing the application of this developed methodology to specific situations, EPA has sponsored two demonstration projects. Each is conducted in conjunction with regional planning programs established earlier under Section 208 of the Federal Water Pollution Control Act, amendments of 1972, which provides for an area-wide approach to water pollution control. The regions selected for the demonstration projects are Knoxville - Knox County Metropolitan Planning Commission, Knoxville, Tennessee, and a tri-state region centered in Cincinnati, Ohio, under the planning direction of the Ohio, Kentucky, Indiana Regional Council of Governments, known as O-K-I. This report describes the work performed in the O-K-I demonstration project.

Application of the methodology in the O-K-I region is tested on a sample consisting of 15 currently operating municipal wastewater treatment plants, selected from among 158 plants in the region, and 3 plants now in the design or construction stage.

Each of the sample plants was surveyed by on-site inspection and by analysis of available records. Case studies developed for each plant (presented in Appendix B) describe location, operation, capacity, service area, and current sludge management methods. The methodology is applied according to pathway analysis, incorporating as many trial iterations as are needed to eliminate infeasible alternatives and to identify the alternatives that appear most suitable for each plant.

In preparation for the discussion and selection of alternatives, presented in Section 8, this report provides background information pertinent to the decision-making process. Section 3 describes economic and institutional characteristics of the O-K-I area, and Section 4 analyzes the environmental setting of the region. Current wastewater treatment and sludge management practices, and projections for the future, are given in Section 5. Section 6 considers briefly the applicable Federal, state, and local regulations affecting air and water quality and land use. Section 7 describes the sludge management alternatives presented in the methodology, indicating the reasons for elimination of several for application in this region. Following the plant-by-plant analysis in Section 8 are possible regional-scale alternatives for sludge management and some of the institutional arrangements that could facilitate region-wide operations.

REFERENCES

II-1 Personal Communication with Dr. Edward Myer. Program Analyst. National Commission on Water Quality. Washington, D. C. December 1975.

II-2 Alternative Waste Management Techniques for Best Practicable Waste Treatment. U.S. Environmental Protection Agency, proposed for public comment. March 1974.

II-3 Wyatt, J.M., and P.E. White, Jr. Sludge Processing, Transportation, and Disposal/Resource Recovery: A Planning Perspective. Engineering-Science, Inc. EPA Contract No. 68-01-3104. April 1975.

3.0 CHARACTERISTICS OF THE STUDY AREA

The study area selected for demonstration of the residual waste management methodology includes all nine counties comprising the O-K-I region. As Figure 3-1 shows, four of the counties lie in southwestern Ohio, three in northern Kentucky, and two in southeastern Indiana. These are respectively, Hamilton, Clermont, Butler, and Warren (Ohio); Boone, Kenton, and Campbell (Kentucky); and Ohio and Dearborn (Indiana).

Major transportation within the region is by rail and by an excellent highway system. Interstate highways 71, 74, and 75 connect the region with the entire Midwest. Interstates 275 and 471 form an encircling connector for the O-K-I area, which is also transversed by a number of state and county arteries. Movement of goods by barge on the Ohio River is active; the region is further served by major airlines as well as numerous smaller commercial and private carriers.

The nine counties encompass 10 major drainage basins. Five basins drain directly into the Ohio River, and five relate to the other major streams in the region: the Licking River, Whitewater River, Great Miami River, Mill Creek, and Little Miami River. Each of the ten major basins contains numerous drainage areas, totalling 233 within the region.

3.1 POPULATION

Analyses of past, present, and future population trends in the O-K-I region provide a base for calculating the anticipated volumes of sludge from each of the wastewater treatment facilities. Table 3-1 presents a population projection, showing an increase from 1,615,347 in 1970 to 2,015,940 in 1990 (Ref. III-1). This increase is equal to an average annual rate of 1.14 percent. Over this 20-year period, Hamilton County will account for about 55 percent of the population in the nine-county area. Interpolation and extrapolation of the values in Table 3-1 indicates that population of the region will be 1,769,742 in 1977 and 2,094,760 in 1995.

3.2 ECONOMIC PROFILE

The economic structure of the O-K-I Region is widely diversified; major activities include manufacturing, commerce, shipping, finance, agriculture, and insurance. Manufacturing and other industrial activities are the preponderant economic pursuits aside from retail trade.

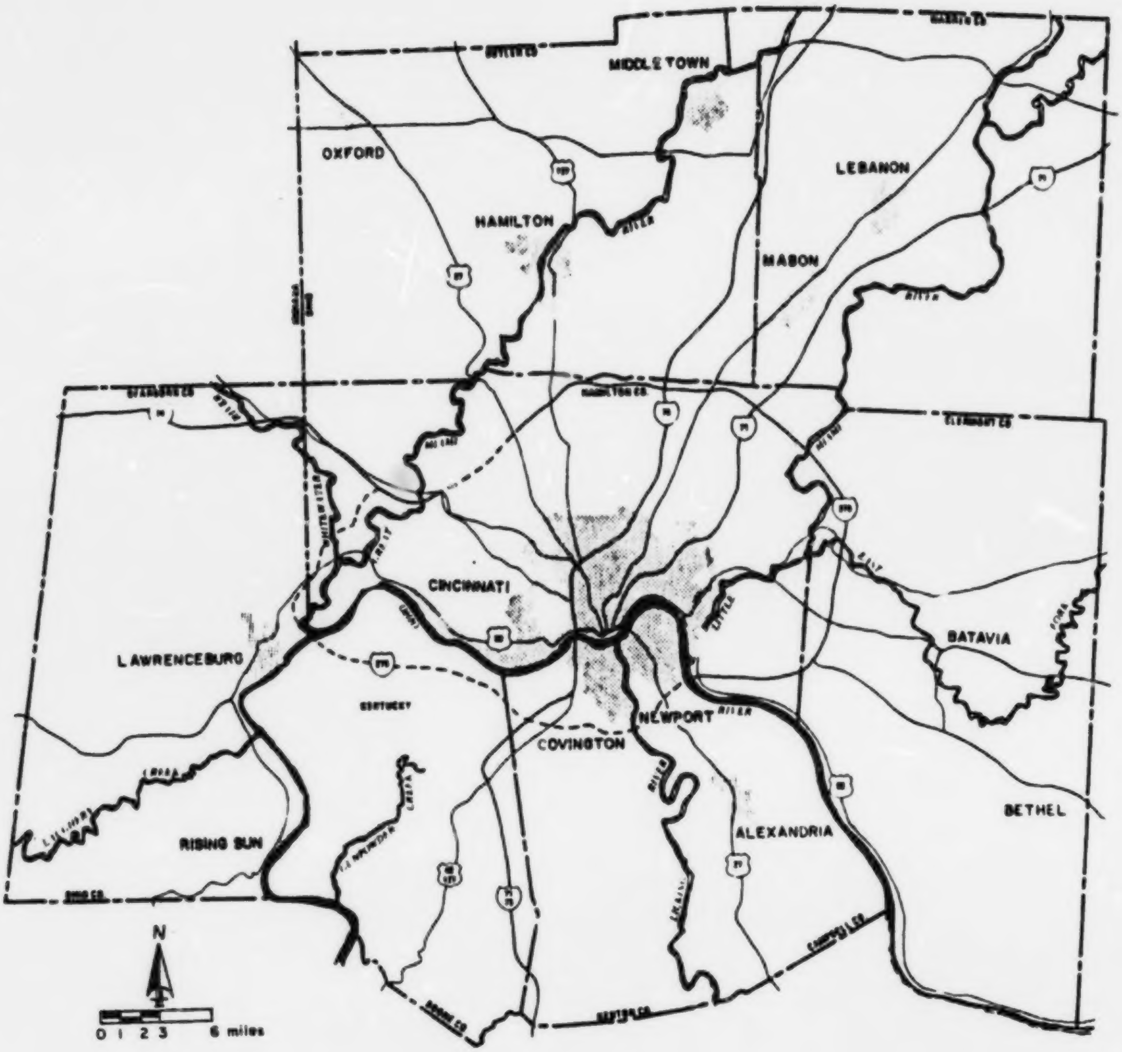

Figure 3-1. Nine county study area.

Table 3-1. POPULATION PROJECTION FOR O-K-I REGION

County	1970	1975	1980	1985	1990
Hamilton	924,018	964,620	1,000,340	1,037,460	1,070,090
Butler	226,207	248,490	267,850	286,260	303,730
Clermont	95,725	117,340	127,550	140,250	150,860
Warren	84,925	106,990	123,900	140,250	156,890
Boone	32,812	34,510	38,260	44,190	48,270
Campbell	88,501	93,180	96,570	99,900	102,580
Kenton	129,440	131,150	136,660	142,170	144,300
Dearborn	29,430	29,850	30,790	32,080	33,190
Ohio	4,289	5,180	5,470	5,760	6,030
O-K-I region	1,615,347	1,731,310	1,827,390	1,928,320	2,015,940

Source: Ref. III-1.

Industry in the O-K-I Region is also diversified. About 77 percent of the industries are located in Hamilton County and the second largest group in Butler County; together these counties account for roughly 85 percent of O-K-I's industry. Ohio and Dearborn Counties contain the fewest industries.

Table 3-2 lists the major industries and indicates the number of establishments for each industry in 1972. Since Hamilton County is near its industrial saturation level, the number of industrial establishments in that county probably will not increase much beyond the present level. Projected land use indicates that the most likely area for industrial development in the O-K-I region is in the corridor extending north of Hamilton County through the cities of Hamilton and Middletown. Further industrial growth may also occur in Boone and Kenton Counties.

Certain industries in the O-K-I region generate liquid wastes that cannot or should not be handled by municipal wastewater treatment plants. Unfortunately, these wastes are occassionally and inadvertently released to the municipal waste stream. Following are the major categories of liquid wastes that must be controlled to allow smooth operation of wastewater treatment plants:

Concentrated sulfuric acid solutions
Concentrated mixed acids
Dilute acid solutions containing chromium and/or other oxidants
Dilute acid solutions containing heavy metals (no chromium or ammonia)
Dilute acid solutions containing heavy metals and ammonium salts
Acidic nitrate solutions containing heavy metals
Alkaline solutions containing cyanides
Alkaline solutions containing sulfide
Concentrated alkalies (no sulfide or cyanide)
Miscellaneous alkaline solutions containing metal
Alkaline wastes with high concentrations of hazardous heavy metals
Combustible organics
Aqueous organic waste streams
Radioactive wastes
Vegetable and animal oils

3.3 INSTITUTIONAL STRUCTURE

As discussed more fully in Section 8.19 of this report, the multiplicity of agencies operating in the O-K-I region may deter the regionalization of waste management. For example, 93 water and sewer agencies are now operating in the area. Of these, approximately 53 agencies have partial responsibility for the collection and treatment of wastewater. These agencies are classified in three categories: (1) public - municipal or county agencies serving one or more communities on a contractual basis; (2) private - independent companies performing wastewater treatment

Table 3-2. MANUFACTURING ESTABLISHMENTS IN O-K-I REGION

(Number and Type - 1972)

Type of Industry	Hamilton	Clermont	Butler	Warren	Boone	Kenton	Campbell	Ohio	Dearborn
Food and kindred products	156	1	11	5	0	11	5	2	7
Tobacco manufacturers	2	0	0	0	0	0	0	0	0
Textile mill products	8	1	0	1	0	1	0	0	0
Apparel and related products	56	0	3	0	1	3	3	0	0
Lumber and wood products	42	5	7	5	0	3	6	0	2
Furniture and fixtures	41	1	7	4	5	3	2	1	1
Paper and allied products	64	3	18	9	3	4	0	0	1
Printing and publishing	287	9	23	7	3	8	10	0	5
Chemicals and allied products	94	3	6	5	0	2	3	0	0
Petroleum and coal products	11	0	2	2	0	0	0	0	1
Rubber and plastic products	62	4	5	3	3	1	0	0	0
Leather and leather products	13	0	0	1	0	0	0	0	0
Stone, clay, and glass products	63	9	25	7	4	7	8	0	6
Primary metal industries	47	2	11	1	0	4	3	0	1
Fabricated metal products	187	3	29	6	5	18	8	0	1
Machinery (except electrical)	256	16	42	14	3	18	10	1	2
Electrical machinery	54	0	4	4	2	4	0	1	0
Transportation equipment	31	3	4	1	0	4	0	0	1
Instruments and related products	39	2	0	0	2	1	1	0	0
Miscellaneous manufacturing	89	4	8	2	1	6	4	1	1
Totals	1602	66	205	77	32	98	63	6	29

Source: United States Census of Manufacturers. Bureau of Census. Washington D.C., 1972.

functions; and (3) special districts - independent agencies serving several communities. Numbers of sewer agencies by county are as follows: Boone 1, Butler 7, Campbell 10, Clermont 6, Dearborn 5, Hamilton 7, Kenton 17, Ohio 1, and Warren 6.

3.3.1 Sewer Districts

The Metropolitan Sewer District of Greater Cincinnati (MSD) is the largest single agency in the O-K-I region. The MSD operates and maintains the Mill Creek wastewater treatment plant (WTP) with its collection network and the Muddy Creek, Little Miami, Sycamore, and Mayflower wastewater treatment plants.

In Hamilton County, with the exception of the villages of Addyston, Cleves, North Bend, and Glendale, and the cities of Loveland and Harrison, all municipalities (28 in number) and all townships (12 in number) are members of the MSD. It is not known what percent of the total population is served by the MSD. Formed originally by Hamilton County and the City of Cincinnati, the District is responsible for the adoption of rules and regulations, the approval of capital improvement programs, and the establishment of rate schedules.

Besides the collection and treatment of wastewater, the District is responsible for (1) inspection, cleaning, repair, and modification of storm sewers in the area; (2) provision of a flood control program in the Mill Creek Valley, (3) sampling and gauging of industrial wastes and (4) control of air pollution. Operation of the MSD is the responsibility of the City of Cincinnati, with ultimate governing control by the Hamilton County Board of County Commissioners.

Sanitary sewer service in northern Kentucky is provided by two special districts. The Sanitation District No. 1 of Campbell and Kenton Counties provides service to approximately 78 percent of the total two-county population; the other district provides service to a very small community in Campbell County, comprising less than 1 percent of the County's population.

Sanitation District No. 1 of Campbell and Kenton Counties, Kentucky is the second largest sewer district in the area (Ref. III-2). The District is responsible for collection and disposal of sewage and other liquid wastes and for street cleaning. The District is controlled and managed by a Board of Directors consisting of three members. At present the District operates and maintains the Bromley wastewater treatment plant. Sewer service charges in northern Kentucky are levied by a number of municipalities as well as by the Sanitation District.

Other sewer districts serving their respective areas include South Dearborn Regional Sewer District, Department of Public Utilities of Middletown, Butler County Sanitary Engineering Department, City of

Hamilton Water and Wastewater Department, The Miami Conservancy District, City of Lebanon, and Clermont County Sanitary District. A number of planning agencies in the area are involved in activities related to waste treatment and disposal as well as in regulation of land uses impinging upon sludge management. Of these, the O-K-I Regional Council of Governments is the largest and the Northern Kentucky Area Planning Commission is second largest. County planning commissions operate in Clermont, Butler, Dearborn, and Warren Counties.

In most counties the collection of municipal refuse is the responsibility of the municipality whether incorporated or not. Disposal, however, is done either by individual municipalities or on a county-wide basis. There are no county garbage districts in the area.

3.3.2 Other Entities

All of the O-K-I region lies in the Ohio River Division of the U.S. Army Corps of Engineers. Development of water resources by the Corps of Engineers in Ohio dates back to the early 1800's. (Ref. III-3) Since then, their activities have expanded to include development and improvement of harbors and navigable channels; preparation of engineering reports on streets, shores and floodplains; construction of flood control, hydropower, and related works, such as for water supply or water recreation; provision of floodplain management services and flood insurance studies; and administration of laws relating to protection of navigable waters, and water quality. Interest of the Corps of Engineers in sludge management follows from its concern with nonpoint sources of pollution affecting the Ohio River. The Urban Studies Program for the O-K-I region will be administered by the Louisville District of the Corps of Engineers. The program will be a cooperative effort of Federal, state, and local governments, emcompassing urban flood control and floodplain management; drainage and urban runoff; water supply management; wastewater management; water - related recreation; and conservation and enhancement of fish and wildlife resources. This program is expected to be underway in fiscal year 1977.

The Ohio River Valley Water Sanitation Commission, ORSANCO, serves the States of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia, and West Virginia. The Commission was formed in 1948 to combat pollution in the Ohio River; (Ref. III-4) one of its major tasks now is to set strict standards applicable to segments of the Ohio River. ORSANCO has set minimum requirements for control of industrial wastes. Preventive measures for minimizing seasonal degradation of river quality by salt-bearing wastes have also been adopted by the eight states. Water-quality surveillance and evaluation is one of the basic functions of the Commission. Chemical and bacteriological data are obtained from 45 sampling stations throughout the interstate district. To supplement these manual measurements, the Commission has developed the ORSANCO

ROBOT MONITOR SYSTEM, which includes (1) electronic units for automatic and continuous analysis of water quality, (2) telemeter transmitters, and (3) data processing facilities.

ORSANCO is developing an analysis of nonpoint sources (agricultural and surface erosion) to determine the need for procedures and facilities for control of pollutants from these sources. This analysis probably will consider sludge management techniques.

The Appalachian Regional Commission has responsibilities over parts of a ten-state area including the eastern part of Clermont County. The major objective of the Commission is to improve the economy of the area. In addition to other public works programs, the Commission offers grants for construction of wastewater treatment facilities and for management of residual wastes.

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4.0 ENVIRONMENTAL SETTING

The O-K-I region is abundant in natural assets, including varied topography, a network of surface waters, and extensive areas of woods and meadowland. Because of these assets the region, unlike most highly populated areas, is profuse in vegetation and wildlife species. As in many parts of the country, however, environmental quality has not been maintained uniformly at a high level. Intermittent episodes of air pollution reach alert levels, and water quality fails to meet the applicable standards at various times. In some locations the absence of land-use controls has allowed careless development, resulting in degradation not only of air and water quality but of natural and aesthetic values. In contrast, some projects, such as development of parks by county-wide and conservancy-type park districts, have yielded measurable improvement of water quality at locations downstream and have enhanced the natural environment.

Application of the methodology for sludge management in the O-K-I region entails the analysis of environmental characteristics, which are factored into the decision-making process as a means of preserving environmental quality.

4.1 LAND USE

Cincinnati is the center of a broad corridor of urban development, as depicted in Figure 4-1. This corridor extends north through Hamilton and Middletown and includes other major urban areas such as Lawrenceburg, Oxford, Lebanon, Mason, Batavia, and Alexandria. The central portions of most of these urban areas have reached peak density and are either stable or deteriorating. The outer portions of the urban areas consist primarily of housing developments, with some industries.

Urbanizing areas as depicted in Figure 4-1 are areas of relatively medium density having substantial potential for new development. Agricultural and rural areas have relatively low density and many have no convenient access to urban centers. These conditions will change gradually with future development of trafficways now planned or projected.

Figure 4-2 depicts projected land use for 1995. The area of the urbanized regions will have increased, thus shifting the urbanizing areas into portions of present rural areas. As a result, the total area of rural and agricultural land use will be reduced.

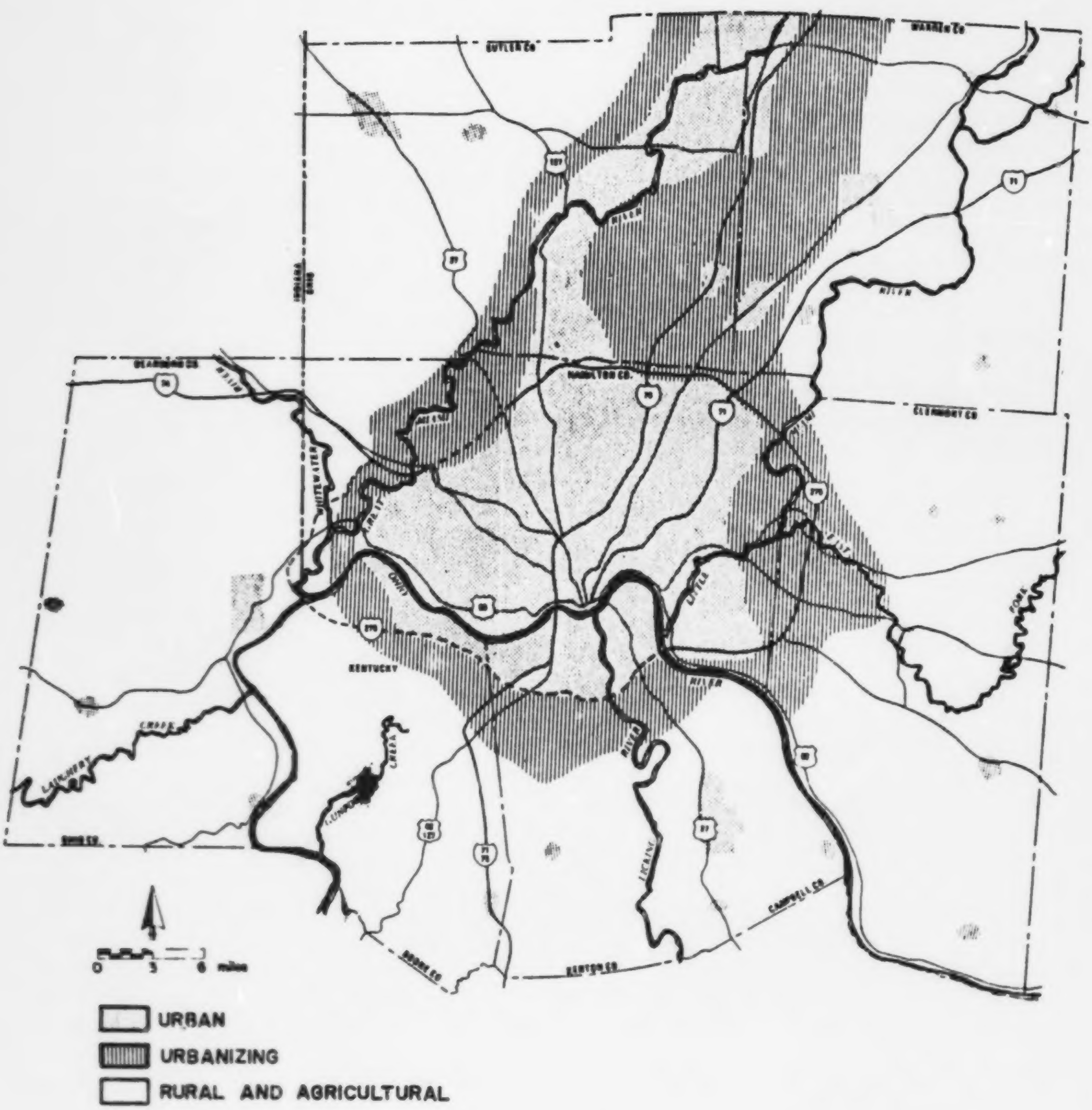

Figure 4-1. Present land use in the O-K-I area.

Source: Ref. IV-1.

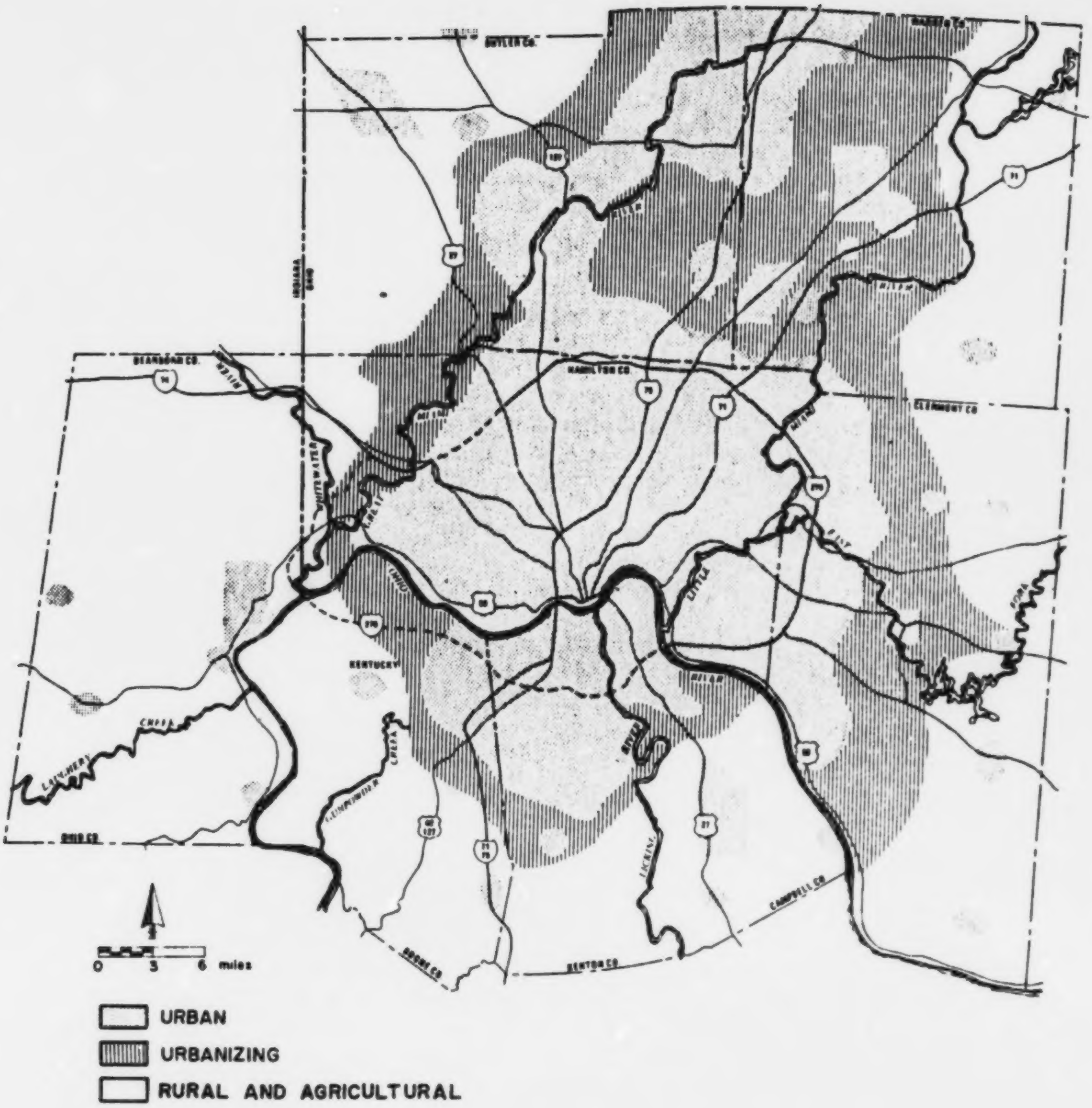

Figure 4-2. Projected 1995 land use for the O-K-I region.

Source: Ref. IV-1.

The increase in urbanized land and the resulting decrease in rural and agricultural land will directly affect the selection of sludge disposal sites. Not only will some presently available space become unavailable for sludge disposal, but transport over greater distances may be required. In addition, sludge generation will increase as a result of both increased population and use of more advanced wastewater treatment techniques. Thus selection of long-term disposal sites must be based on consideration of land development trends.

4.2 TOPOGRAPHY

The O-K-I area is basically a low plateau bisected by the Ohio River and its tributaries to produce a network of valleys and ridges, some with considerable slope. The most rugged topography is in Hamilton, Dearborn, and Ohio counties. Clermont County is relatively flat except in the western portions along the rugged banks of the Little Miami River. Kenton and Campbell counties form a low plateau cut by the Ohio and Licking rivers. Extensive erosion has developed narrow valleys and ridges. Boone County, though generally flat, contains steep slopes in the western portion and gently rolling hills in the central portion.

Glaciers have cut three major valleys in the region, traversed by three major rivers that run south to the Ohio. In the western area the Great Miami River flows southwest from the Warren-Butler County line to the Ohio River. South of Hamilton the Mill Creek flows south through Hamilton County into the Ohio River. The Little Miami River passes through eastern Warren County before forming the Clermont-Hamilton County border and emptying into the Ohio River.

4.3 SOILS

Thirteen basic soil associations are recognized in the O-K-I region (Ref. IV-2,3,4,5). A soil association is the landscape having distinctive proportioned patterns of soils, normally including one or more major soils. The soils in one association may occur in another, but in a different pattern. Figure 4-3 shows the various soil associations and their distribution in the O-K-I area. The name of each association is constructed so that the major soil (series) is listed first, followed by the second and third major soils; the name does not indicate minor soils. Table 4-1 lists characteristics of the soil association, such as permeability, water table, and hardpan. This table, together with the delineation of soil associations in Figure 4-3, can be useful to planners by indicating dominant soil patterns in the O-K-I region and location of large tracts possibly suitable for certain kinds of land use, including sludge disposal. Areas that have low-permeability soils or hardpan and are not subject to seasonal flooding have some potential as sludge disposal sites. Figure 4-4, depicting the range of slopes over the region, indicates relative accessibility of potential disposal sites.

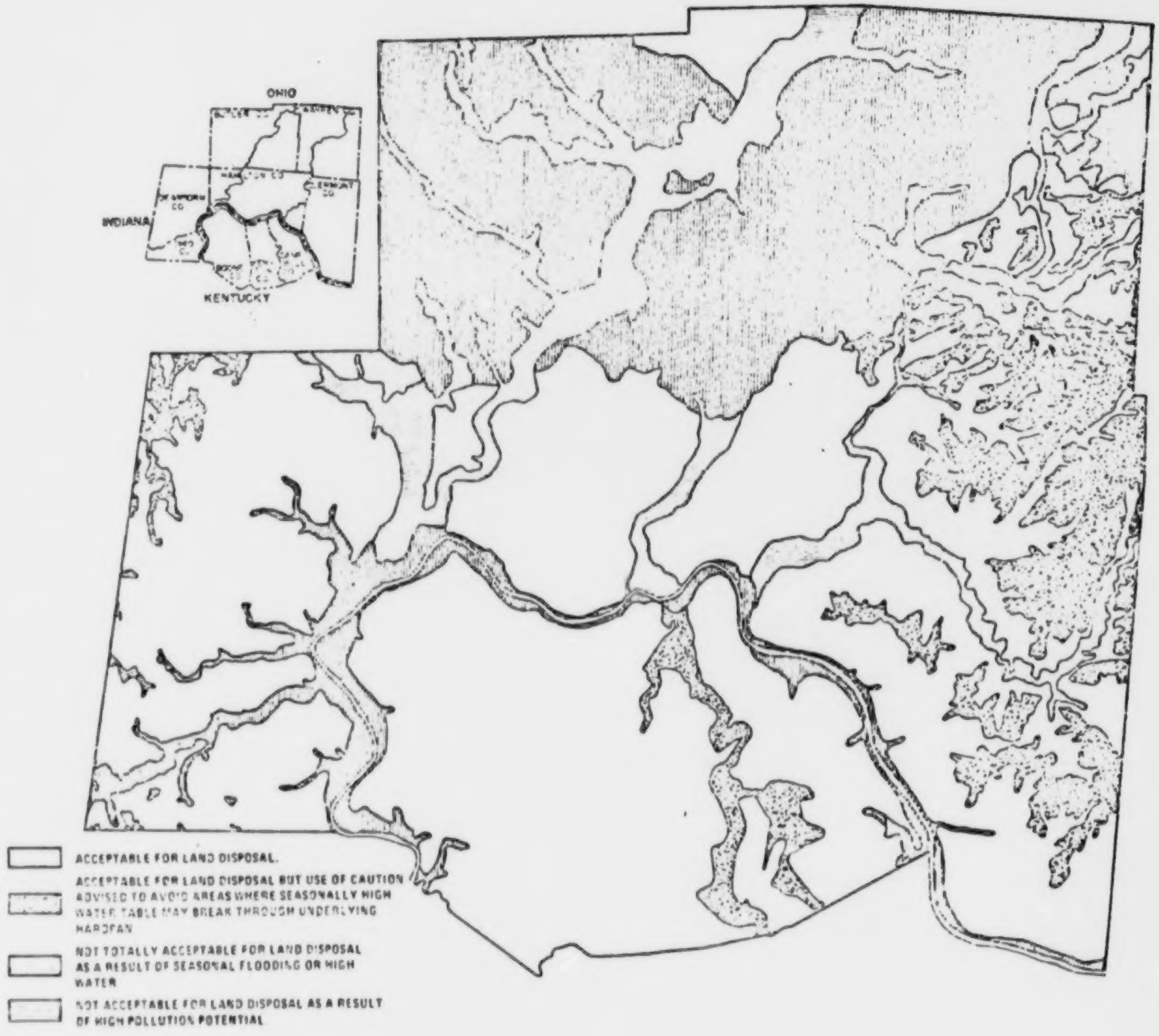
OHIO
INDIANA
KENTUCKY
HAMILTON CO
CLERMONT CO
DEARBORN CO
BUTLER CO
ACCEPTABLE FOR LAND DISPOSAL.
ACCEPTABLE FOR LAND DISPOSAL BUT USE OF CAUTION ADVISED TO AVOID AREAS WHERE SEASONALLY HIGH WATER TABLE MAY BREAK THROUGH UNDERLYING HARDPAN
NOT TOTALLY ACCEPTABLE FOR LAND DISPOSAL AS A RESULT OF SEASONAL FLOODING OR HIGH WATER
NOT ACCEPTABLE FOR LAND DISPOSAL AS A RESULT OF HIGH POLLUTION POTENTIAL

Figure 4-3. Soils classifications in the O-K-I area for sludge disposal.
Source: Ref. IV-5

Table 4-1. SOIL ASSOCIATIONS WITHIN THE O-K-I REGION

Soil association	Permeability	Subject to seasonal high water table or seasonal flooding	Underlain by a hardpan
Miami-Celina-Milton	Moderately low	No	No
Russel-Xenia-Wynn	Moderately low	For short periods	No
Fincastle-Xenia-Brookston	Moderately low	For extended periods	No
Fincastle-Montgomery-Eel	Moderate	Seasonal high water table and flooding	No
Patten-Henshaw	Moderate	Perched water table winter and spring	No
Rossmoyne-Cincinnati-Edenton-Jessup	Moderate to moderately slow	No	Yes
Avonburg-Clermont	Slow	High water table winter and spring	Yes
Genesee-Fox-Eel	Moderate	Seasonal flooding	No
Huntington-Wheeling	Moderate	Periodic flooding	No
Licking-Captina	Slow	Seasonal flooding and perched water table	Yes
Faywood-Nicholson	Slow	Perched water table winter and spring	Yes
Fairmont-Faywood-Edenton	Slow	No	No
Eden-Cynthiana	Slow	No	No

Source: Ref. IV-2, 3, 4, 5

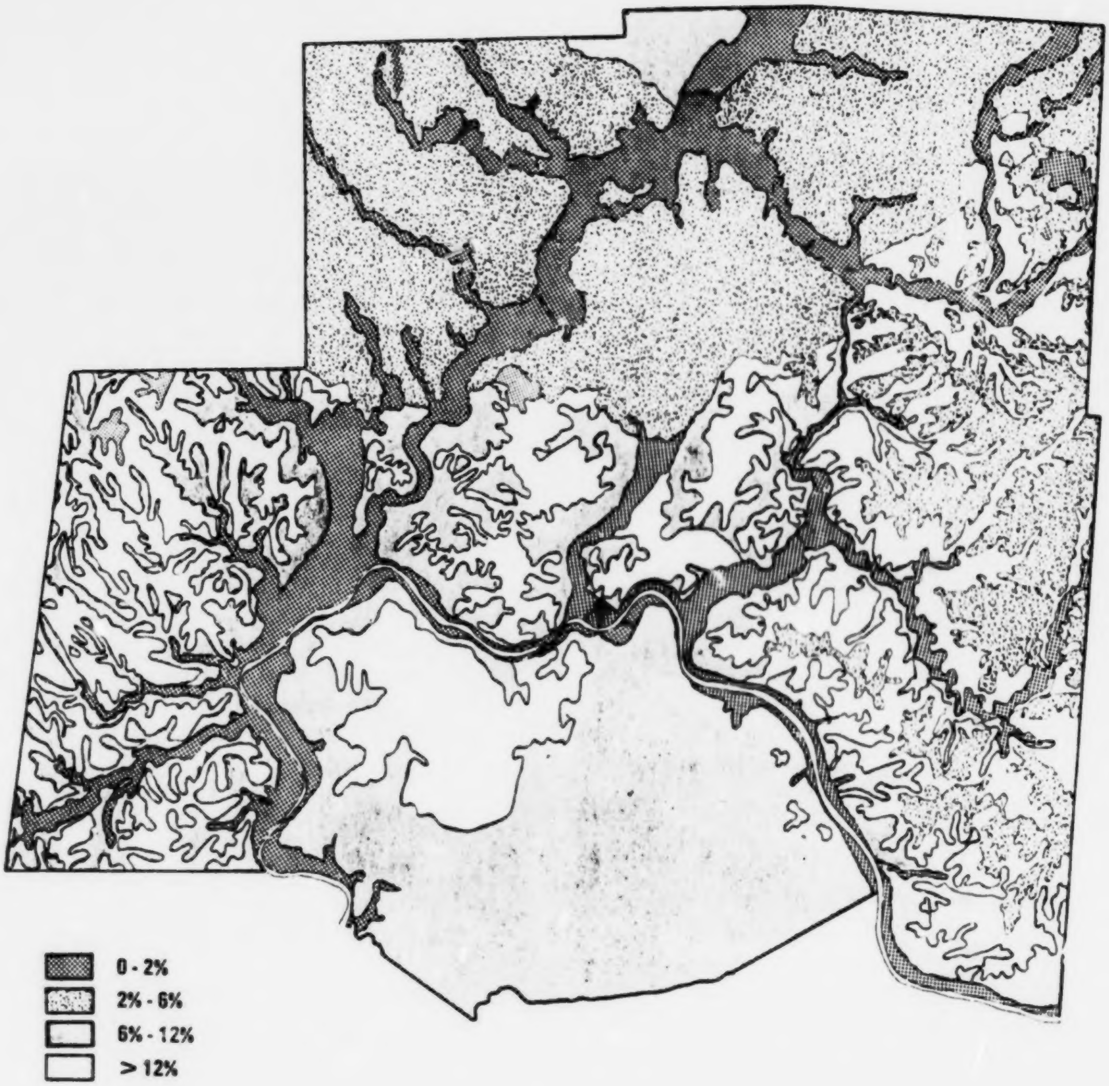

Figure 4-4. Slope characteristics of the O-K-I region.

Source: Ref. IV-6.

4.4 GEOLOGY

Bedrock formations in the O-K-I region belong to the Ordovician System, which occured between 430 and 500 million years ago. The formations that underlie the area consist almost exclusively of shale and limestone arranged in nearly horizontal beds. Sandstone is present in very limited quantities. Beds of limestone and of shale alternate at frequent intervals, the total thickness of the shale exceeding that of the limestone. Thickness of the limestone beds ranges from 1 inch (2.54 cm) to more than 1 foot (0.3 m). Beds of limestone, rarely found in contact, are generally separated by beds of shale, which may be paper thin or as much as 5 or 10 feet (2 or 3 m) thick. The maximum outcroppings of bedrock are about 600 feet (180 m) thick (Ref. IV-7).

These bedrock formations are usually covered by residual soils from bedrock, silt and loess soils due to wind transportation, clays of the Wisconsin Age, and alluvium soils due to water transportation. Because of the porosity of limestone, some sludge disposal methods could adversely affect groundwater quality.

4.5 HYDROLOGY

The Ohio River has three major tributaries in the O-K-I region; from the north, the Great Miami and Little Miami Rivers; and from the south, the Licking River. These major streams, together with several lesser streams and extensive groundwater aquifers that underly them, provide the region with an abundant water supply.

Groundwater occurs in varying quality and quantity in the region. In upland areas groundwaters are sparse and of poor quality. Rocks under the upland yield a little water to shallow wells, primarily for domestic use. Major supplies of groundwater are found in valleys of the Little Miami-Mill Creek, the Great Miami-Whitewater, and the Licking Rivers.

Principal groundwater sources in the Little Miami and Mill Creek Valleys are the sand and gravel deposits. The Little Miami aquifer, from south of Loveland to Milford, develops 100 to 500 gallons per minute (gpm) (0.38 to 1.9 m^3/min). The valley south of Milford to the Ohio River can support wells that yield 500 to 1,000 gpm (1.9 to 3.8 m^3/min). Yields of 100 to 500 gpm (0.38 to 1.9 m^3/min) can be expected in the Mill Creek Valley aquifer from the Ohio River to the Hamilton County corporation line. Recharging of this aquifer is limited by a fairly continuous impermeable layer of clay. Water from these two valleys is hard and usually contains objectionable amounts of iron and manganese (1 ppm or greater). The water is classified as "fair" in quality and is unsuitable for domestic and industrial use unless treated appropriately.

Lower portions of the Great Miami Valley are reported as the most abundant groundwater reservoir in Ohio. Highest yields (up to 3,000 gpm) (11.4

m^3/min) are obtained where the sand and gravel aquifer is near the river or other major streams, where recharge induced from the stream will sustain pumping. Where there is no recharge capability, pumping rates range from only 500 to 1,000 gpm (1.9 to 3.8 m^3/min). The least favorable groundwater supplies occur in valleys buried in clay, where wells yielding only 5 to 10 gpm (0.02 to 0.04 m^3/min) are common. The water table in the area ranges from 15 to 50 feet (4.6 to 15.3 m) below the land surface, with seasonal fluctuations of 5 to 15 feet (1.5 to 4.6 m) annually. The quality of the groundwater is good, typically with dissolved materials of 400 to 500 ppm. Contamination of groundwater, though detectable, has as yet been minor. Small amounts of phenol and "hard detergents" have been detected (Ref. IV-6).

Groundwater supplies in the Licking River Valley are adequate for domestic use but probably not for large industrial use. Wells drilled in permeable materials yield as much as 300 gpm (1.1 m^3/min), whereas wells drilled in alluvium yield no more than 60 gpm (0.23 m^3/min) at a depth of 100 to 150 feet (31 to 46 m).

Surface water supplies in the region account for 78 percent of the total water processed in 1968. This percentage is expected to continue at least through 1990. Figure 4-5 shows three classifications of groundwater accessibility. This brief review of the region's hydrology suggests that as possible sites for sludge disposal, the upland areas seem most suitable and offer the least probability of adverse impact.

4.6 CLIMATE

Climate in the O-K-I region is temperate and humid. The average temperature for January is about 33F (0.6C), for July 76F (24C), and for the year, 54F (12C). Average annual rainfall is about 40 inches (102 cm), distributed fairly well throughout the year. Although droughts do occur, rains are usually adequate for normal growth of crops. The average growing season is 186 days.

Thunderstorms occur on an average of 50 days a year. Though more frequent from March to August, they may occur in any month. Most of the high-intensity rains occur as summer thundershowers. Lighter spring rains sometimes persist for several days and delay tillage. The prolonged rains are most likely to cause flooding because they occur when the soils are frozen, snow covered, or saturated. Long periods of mild, sunny weather are typical of the fall harvest season (Ref. IV-4).

Prevailing winds are from the southwest; wind velocities average 8 miles per hour (3.6 m/sec) in summer and 11 miles per hour (4.9 m/sec) in winter. Damaging winds of 30 to 80 miles per hour (13.4 to 35.8 m/sec) are associated with thunderstorms.

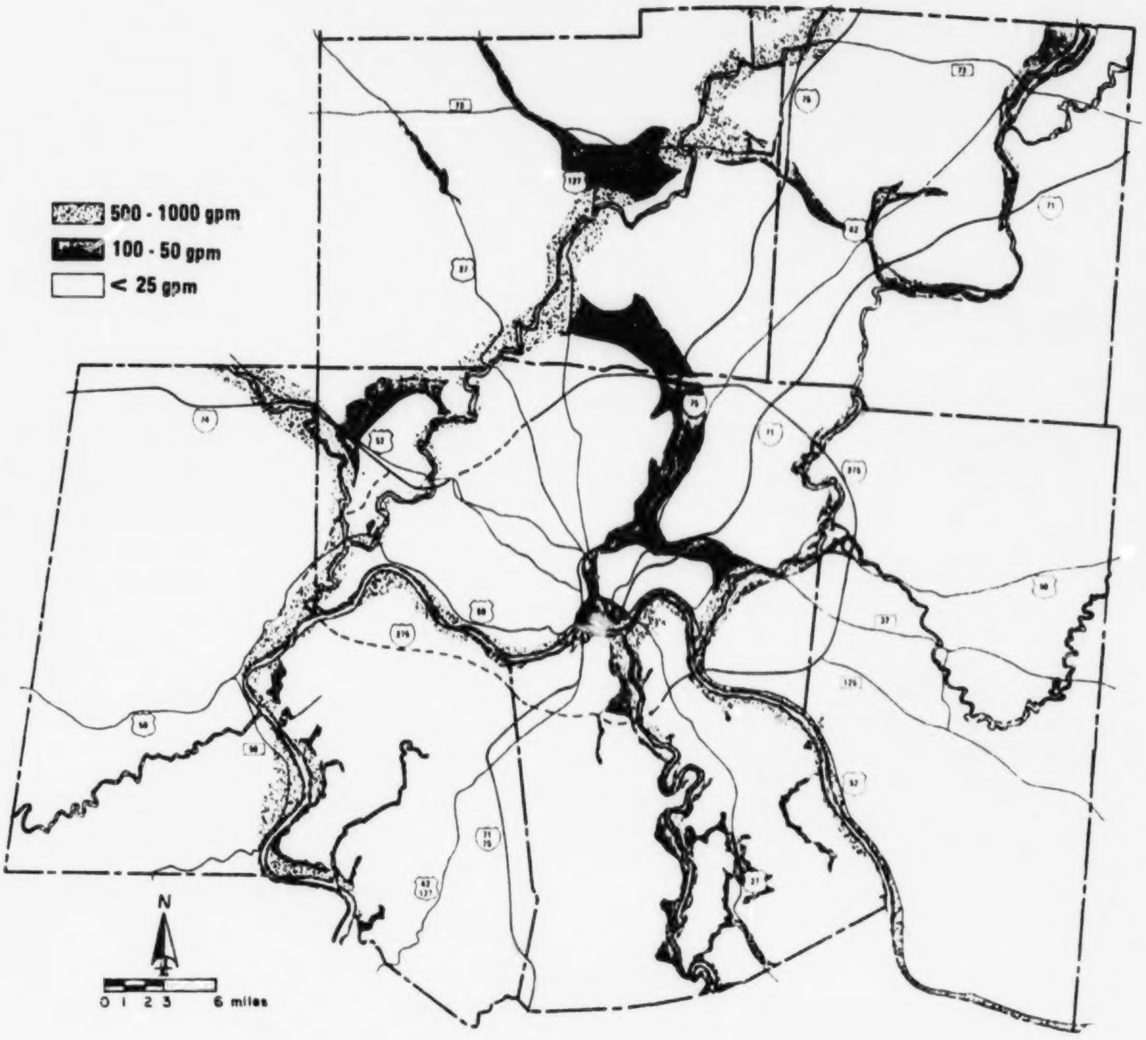

Figure 4-5. Groundwater availability in O-K-I region.

Source: Ref. IV-12, 13, 14.

Climatological information is particularly useful for determining those weather conditions in the O-K-I area which impinge most adversely on sludge disposal by landfilling or land spreading.

4.7 WILDLIFE AND VEGETATION

Wildlife and vegetation are important natural resources of the O-K-I region. The kinds of wildlife and vegetation in a given area, and the numbers of each kind, are closely related to land use as well as other environmental factors. The welfare of any species of wildlife depends on the presence and adequate distribution of food plants, shelter plants, and water. When any one of these habitat elements is absent, inadequate, or inaccessible, the species becomes scarce in the area or absent entirely.

Three basic kinds of wildlife, based on habitat, are present to some extent in the O-K-I region: open land wildlife, woodland wildlife, and wetland wildlife. Table 4-2 lists typical wildlife species occurring in these areas.

Open wildlife areas include cultivated fields, abandoned fields that have not yet reached advanced stages of secondary succession, and pastures. Typical vegetation (both wild and cultivated) common to open habitats in the O-K-I region is listed in Table 4-3. Woodland areas include both deciduous and coniferous forests. Continued establishment of pure coniferous forests, however, is unlikely since they are not well suited to compete with local hardwoods. Typical vegetative species occurring in woodland areas are listed in Table 4-4. Wetlands, which include ponds, swamps, and marshes, are moist to wet sites that support vegetation specifically adapted to this environment. Typical vegetation common to these habitats is listed in Table 4-5.

Tables 4-2 through 4-5 are by no means complete for the O-K-I region but are presented rather to indicate the quality of fauna and flora in the area, which must be considered in selection of a sludge disposal site. If it is determined that a proposed site contains a unique habitat or that adverse impacts to flora and fauna, to the site, or to surrounding areas might be irreversible, an alternative site should be selected.

4.8 WATER AND AIR QUALITY

Consideration of water quality in the O-K-I region is focused on the Ohio River. Quality of water in tributary streams, direct discharges to the Ohio, and nonpoint sources throughout the area will ultimately affect the Ohio River.

Table 4-2. TYPICAL WILDLIFE SPECIES OCCURRING IN OPEN LAND, WOODLAND, AND WETLAND IN THE O-K-I REGION

Species[a]	Occurring in openland	Occurring in woodland	Occurring in wetland
Rabbit	x	x	x
Quail	x	x	x
Squirrel		x	
Dove	x	x	
Raccoon		x	
White tail deer	x	x	
Woodchuck	x		
Crow	x		
Chipmunk	x	x	
Bat		x	
Mouse	x	x	x
Shrew	x	x	x
Mole	x	x	
Ring-necked Pheasant	x	x	
Badger	x		
Gray fox		x	
Red fox		x	
Mink			x
Striped skunk		x	
Opossum		x	
Muskrat			x
Beaver			x
Woodcock		x	
Thrush		x	
Red-winged Blackbird	x	x	x
Vireo		x	
Scarlet Tanager		x	
Woodpecker		x	
Mallard Duck			x
Black Duck			x
Wood Duck		x	x
Scaup			x
Gadwall			x
Goldeneye			x
Pintail			x
Baldpate			x
Mergansers			x
Bufflehead			x
Green-winged Teal			x
Canvasback			x
Redhead			x
Widgeon			x
Blue wing teal			x
Canada goose	x		x
Coot			x
Blue goose			x
Red Cockaded Woodpecker[b]		x	x
Kildeer			x
Whippoorwill		x	
Sparrow	x	x	
Phoebe	x	x	
Hawk	x	x	
Heron		x	x

[a] The species listed may only potentially inhabit the areas indicated and in the case of migratory species only during migrating period.

[b] The Red Cockaded Woodpecker is listed as an endangered species by both the U.S. Department of the Interior and the State of Kentucky. It is very possible that this species is present in the O-K-I area. Therefore, special care should be taken when intruding areas of diseased and dead pines since this species nests in such areas.

Source: Ref. IV-15

Table 4-3. VEGETATIVE SPECIES (WILD AND CULTIVATED) OCCURRING IN OPEN AREAS IN THE O-K-I REGION

- Corn
- Soybean
- Dwarf sorghum
- Wheat
- Barley
- Oats
- Rye
- Kentucky Bluegrass
- Tall Fescue
- Smooth Brome
- Timothy
- Redtop
- Orchard Grass
- Switchgrass
- Red Clover
- Alside Clover
- Birdsfood Trefoil
- Alfalfa
- Pigweed (R)
- Pokeweed
- Strawberry
- Raspberry
- Blueberry
- Elderberry
- Sunflower
- Dandelion
- Foxglove
- May apple
- Virginia Spring Beauty
- Harebell
- Smooth Yellow Violet
- Birdsfoot Violet
- Shooting Star (R)
- Red Trillium
- Yellow Trout Lily
- Squirrel Corn
- Milkweed
- Thistle
- Daisy
- Goldenrod
- Ragweed
- Smartweed
- Nightshade
- Blackberry

(R) - Rare.

Source: Ref. IV-15

Table 4-4. TYPICAL VEGETATIVE SPECIES OCCURRING IN WOODLAND AREAS IN THE O-K-I REGION

- Chinquapin Oak
- White Oak
- Chestnut oak
- Pin Oak
- Shingle Oak
- Black Oak
- Red Oak
- Scarlet Oak
- Maple
- Aspen
- Rose
- Brier
- Sassafras
- Black Locust
- Beech
- Green Ash
- White Ash
- Hackberry
- Wild Cherry
- Mulberry
- Dogwood
- Hawthorne
- Blackhaw
- Hedgeapple
- Elderberry
- Paw Paw
- Walnut
- Shagebark Hickory
- Shellbark Hickory
- Bitternut Hickory
- Mockernut Hickory
- Pignut Hickory
- Red Hickory
- Poplar
- White Pine
- Cedar
- Wild Grape
- Sumac
- Hazelnut
- Elm
- Honey Locust
- Broomsedge
- Autumn - Olive
- Amur Honeysuckle
- Tatarian Honeysuckle
- Crabapple
- Virurnum
- Indianpipe
- May Apple
- Snowy Orchid (R)
- Red Helmet (R)
- Cut Toothwort

R - Rare for the O-K-I region as designated by the local Department of Natural Resources.

Source: Ref. IV-15

Table 4-5. TYPICAL VEGETATIVE SPECIES OCCURRING IN WETLAND AREAS IN THE O-K-I REGION

Arum Arrowhead
Turtle Head
Smartweed
Wild Millet
Rush
Bulrush
Cattail
Spikerush
Sedge
Burreed
Wildrice
Buttonbush
Rice Cutgrass

Source: Ref. IV-15.

4.8.1 Water Quality

Dissolved oxygen (DO) levels in the upper Ohio River near Pittsburgh meet the state standards, based on warm-water aquatic life requirements, as the result of the late-1973 completion of secondary treatment facilities at the Allegheny County Sanitary Authority plant serving the Pittsburgh metropolitan area (Ref IV-16).

In the river section from Cincinnati to below Louisville, the State DO standards are not met during variable periods of the summer and fall months. Completion of secondary wastewater treatment facilities either planned or under construction, will probably result in compliance with DO standards under most river flow conditions.

In addition to warm-water aquatic life, the Ohio River is classified for primary (body contact) recreation and for public and industrial water supply. Only limited sections of the river, however, meet the state standards for total or fecal coliform in waters used for recreation or for public supply. Improvements in disinfection of municipal and some industrial discharges could reduce fecal coliform levels in the river. Nonpoint sources of total and fecal coliform bacteria will be a major factor in determining future compliance with State standards. Moreover, occasional high values for hexavalent chromium, copper, lead, and mercury exceed the applicable standards. Variations in levels of these and other substances (nitrogen and phosphorous compounds, iron, manganese, arsenic, silver and other trace materials) are in part related to nonpoint sources of pollutants such as urban and rural runoff, and to certain industrial contributions to municipal wastewater treatment facilities that are not degradable by current biological methods.

With completion of presently required improvements of point source discharges, nonpoint sources of pollutants will become a more influential determinant of Ohio River water quality. Methods of sludge disposal or resource utilization will play a key role in controlling nonpoint source pollutants entering the Ohio River and its tributaries.

4.8.2 Air Quality

Attainment of the national primary air quality standard for particulates in the metropolitan Cincinnati Interstate Air Quality Control Region (AQCR 79) is an ongoing task. In 1974, the State and local agencies involved in the management of AQCR 79 reported 21 violations of the primary particulate standard of 75 $\mu g/m^3$ annual geometric mean (Ref. IV-17). Nineteen of those reported violations were in the State of Ohio, and two were in Kentucky.

Implementation and completion of all compliance action for particulate control will allow the AQCR 79 to attain and maintain compliance with the Standard (75 $\mu g/m^3$). Any addition to an existing facility or construction of a new facility that involves the discharge of air contaminants would be required to install and maintain equipment that ensures compliance with the applicable Federal and State regulations. Compliance with air pollution control regulations is a key consideration in the assessment of alternatives for regional sludge management. A more complete delineation of air pollution standards for the O-K-I region is referenced in Section 6 of this report.

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IV-17 Environmental Protection Agency Regulations on National Primary and Secondary Ambient Air Quality Standards. 40 CFR 50; 36 FR 22384, November 25, 1971, as amended by 38 FR 25678, September 15, 1973; 40 CFR 7042, February 18, 1975.

5.0 WASTEWATER TREATMENT AND SLUDGE MANAGEMENT

This chapter reviews the current sludge handling and disposal options at selected plants, describes the characteristics of the wastewater sludges in the O-K-I region, and projects the quantities of sludge to be generated in the O-K-I area to the year 1995.

5.1 OPERATING AND PROPOSED WASTEWATER TREATMENT FACILITIES

A sample of 15 operating plants and 3 proposed wastewater treatment facilities (Figure 5-1) was selected for demonstration of the methodology. They were selected from among a total of 158 plants in the O-K-I area (Figure 5-2). A complete listing of wastewater treatment facilities in the O-K-I region is given in Appendix A. One criterion for selection of demonstration plants was whether a NPDES permit had been issued as of April 30, 1975. The plants are distributed over the entire region to account for variations in environmental, institutional, and legal constraints, if any, in evaluating sludge disposal alternatives.

Capacities of the sample plants, based on daily average dry weather flow, range from 120 mgd (456,000 m^3/d) serving a population of over one-half million to 35,000 gpd (133 m^3/d) serving about 200 homes. The current and proposed sludge handling and disposal methods and the plant operating data were examined onsite. Detailed case studies are given in Appendix B. Table 5-1 summarizes the types and quantities of sludge produced at each plant. The sample plants as listed in Table 5-1 represent about 80 percent of the treatment capacity in the O-K-I area and generate about 252 tons (228 metric tons) per day of sludge on a dry basis. The 18 plants serve a domestic population of over a million people.

Table 5-2 shows the quantities of grit and screenings now generated at the plants. Most plants dispose of the grit and screenings at a nearby landfill.

5.2 SOURCES AND CHARACTERISTICS OF MUNICIPAL WASTEWATER TREATMENT RESIDUALS

The characteristics of municipal wastewater treatment residuals in the O-K-I region are highly variable and are determined by one or more of the following factors:

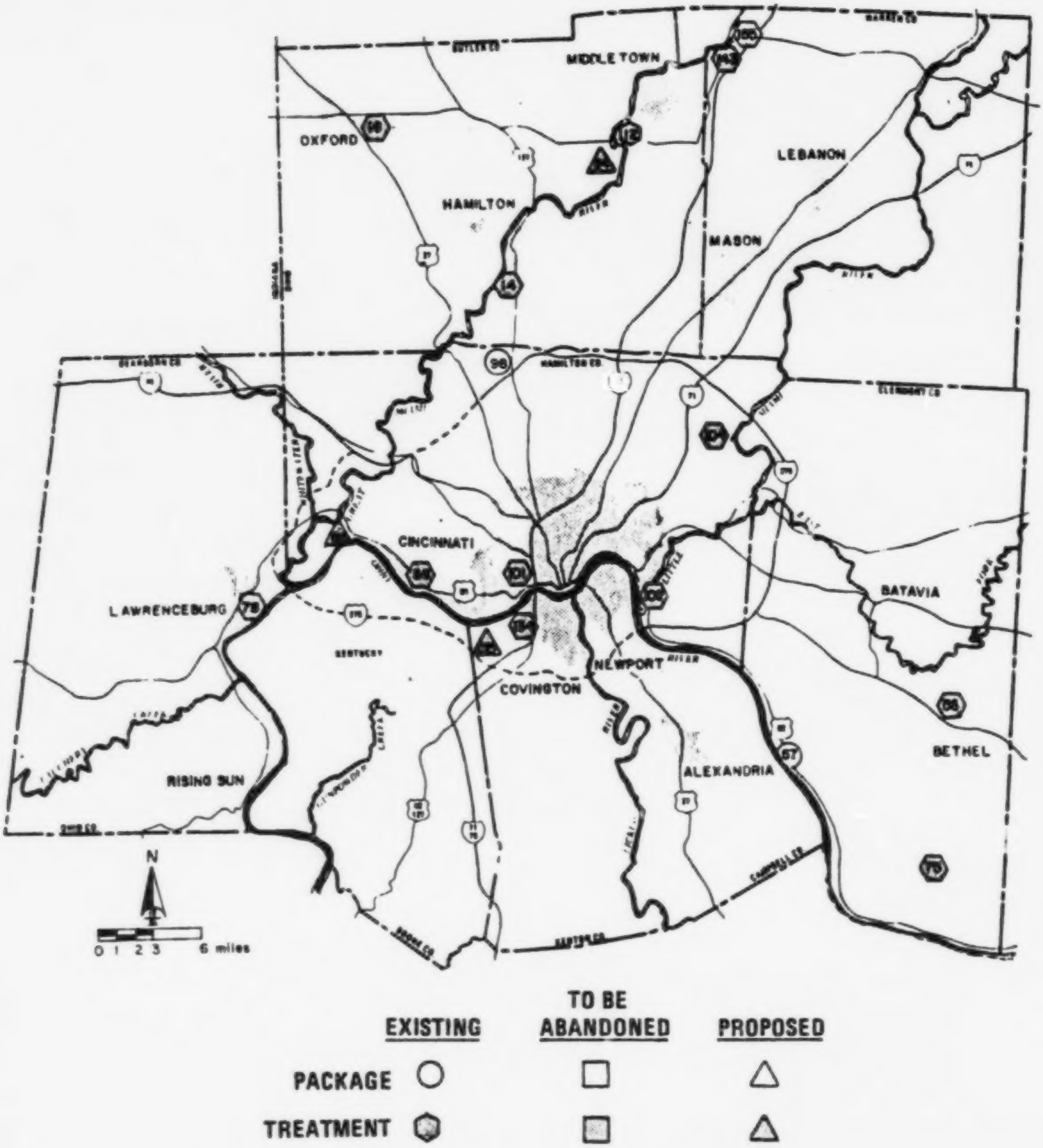
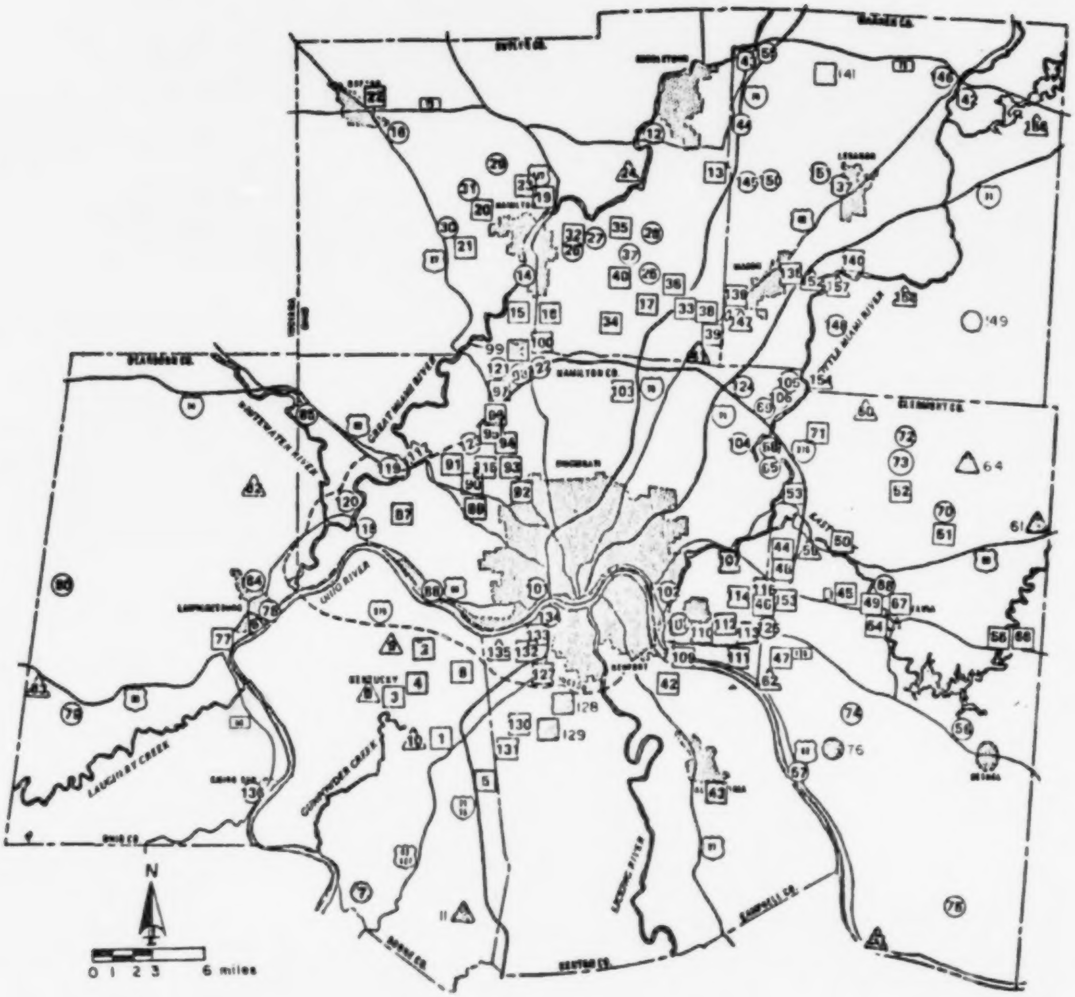


Figure 5-1. Wastewater treatment facilities selected as sample plants.



	EXISTING	TO BE ABANDONED	PROPOSED
TREATMENT	○	□	△
PACKAGE	○	□	△

Figure 5-2. All wastewater treatment facilities in the O-K-I region.

Table 5-1. SUMMARY OF EXISTING AND PROPOSED WASTEWATER TREATMENT FACILITIES SHOWING THE TYPE AND QUANTITY OF SLUDGE GENERATED

	Plant[a]	Sludge type	Average daily flow, (mgd)	Sludge			Domestic population	lb/cap day[b]
				Wet (ton/day)	Solids, (%)	Dry (ton/day)		
1	Mill Creek	Raw sludge	120	1,987	5	99.35	500,000	0.40
2	Little Miami	Raw sludge	31	417	5	20.85	170,000	0.25
3	Bromley	Raw sludge[c]	20.8	197	3.8	7.5	170,000	0.09
4	Middletown	Raw sludge	10.0	103	7	7.2	55,000	0.26
		Waste activated sludge[c]		410	1	4.1		0.15
5	Franklin Area WTP	Raw sludge (Industrial)		229	7	16.0	Industrial	
		Raw sludge (Domestic)	9.0	17	6	1.0	11,000	0.18
6	Muddy Creek	Raw sludge	8.3	117	6	7.0	63,000	0.22
		Waste activated sludge		30	1	0.30		0.01
7	Hamilton	Raw sludge	7.0	254	3.5	8.90	70,000	0.25
8	Sycamore	Raw sludge	3.5	58	4	2.32	30,000	0.15
		Waste activated sludge		66	0.5	0.33		0.02
9	Oxford	Raw sludge with return secondary sludge	2.64	37	6	2.2	21,700	0.20
10	Lawrenceburg	Industrial sludge[d]	1.4	333	0.3	1.0	Industrial	
		Waste activated sludge[e]	2.5	950	2	19.0	15,000	2.5
11	Bethel	Raw sludge anerobically digested	0.47	6	4	0.23	2,400	0.19
12	New Richmond	Waste activated sludge[c]	0.1	0.8	1	0.008	1,725	0.01
13	Felicity	Waste activated sludge	0.081	1	1	0.01	650	0.03
14	Mayflower	Waste activated sludge	0.035	11	1	0.114	600	0.38
15	Systech	Various industrial	0.045				Industrial	
16	Dry Creek	Raw sludge	30	410	5	20.5	270,000	0.15
		Waste activated sludge		3,050	1	30.5		0.22
17	LeSourdsville	Raw sludge	4	25	4	1.0	40,000	0.05
		Secondary sludge[c]		86	2.5	2.14		0.11
18	Cleves-North Bend	Raw sludge sludge with secondary sludge[c]	0.5	20	4	0.80	4,980	0.32

[a] Plant No. 1 thru 15 are operating; 16 thru 18 are proposed.
[b] Data in this column are calculated. Data in all other columns obtained from plant operators.
[c] Chemical added
[d] Plant No. 1.
[e] Plant No. 2.

1 mgd = 3,800 m^3/d
ton x 0.908 = metric ton

Table 5-2. GRIT AND SCREENINGS PRODUCED FROM OPERATING PLANTS

Plant	Grit (ft^3/day)	Screenings (ft^3/day)
1. Mill Creek	125	20
2. Little Miami	3	5
3. Bromley	11	N.A.
4. Middletown	22	12
5. Franklin	N.A.	N.A.
6. Muddy Creek	30	9
7. Hamilton	5.5	N.A.
8. Sycamore	5	3
9. Oxford	4	9
10. Lawrenceburg	20[a]	N.A.
	7[b]	N.A.
11. Bethel	2	<1
12. New Richmond	N.A.	N.A.
13. Felicity	N.A.	N.A.
14. Mayflower	N.A.	N.A.
15. Systech	c	c

[a] Plant No. 1.

[b] Plant No. 2.

[c] Industrial Pretreatment Facility; No Grit and Screenings.

N.A. - Implies not known.

1 mgd = 3800 m^3/d·

1 ft^3 = 0.028 m^3/d

Source: Personal contacts with Plant Operators.

1. Origin of the sludge
2. Wastewater treatment process
3. Sludge treatment process

Of the 15 sampled operating wastewater treatment plants, 6 handle strictly municipal wastewater, 8 handle combined domestic and industrial wastewater, and 1 plant handles only industrial wastes (Table 5-3).

Primary municipal sludge is greyish, usually with a distinct offensive odor. Solids content of the raw sludge ranges from 3.5 to 7 percent. Activated sludge is brown, with an average solids content of 1 to 3 percent. The composition of residuals from domestic wastewater treatment plants is fairly uniform.

Characteristics of the sludge from plants handling combined domestic and industrial wastewater depend on the quantity and type of industrial wastewater and whether it has undergone pretreatment. Sludge from one plant that handles strictly industrial wastewater has a fibrous texture and a slight reddish-brown tint due to the presence of iron; it has no odor.

Screenings usually have high organic and moisture contents and a putrescent odor. Grit is inorganic, with little odor.

Sludge from the Franklin Wastewater Treatment Plant is unique in the area. This plant receives a large quantity of industrial waste from the nearby Systech Plant. The sludge from the primary clarifier, which treats mainly industrial influent, is pumped to adjacent farmland for soil conditioning. This practice has been in effect for about 3 years. With the permission of the Miami Conservancy District, a sample of the dried sludge was analyzed at the PEDCo laboratory. The results, given in Table 5-4, show a cadmium content that is approximately 18.7 percent of the zinc content. Recent EPA guidelines for the utilization of sludge (Ref. V-1), recommend that sludge having a cadmium content greater than 1 percent of its zinc content should not be applied to cropland except under special conditions.

5.3 PROJECTED SLUDGE QUANTITIES FOR THE O-K-I AREA POPULATION

The total population of the O-K-I region in 1975 is estimated to be 1,731,310 (Ref. V-2). By the year 2000, the population is projected to be 2.17 million. The population is now concentrated in a very small region along the major streams and highways. It is anticipated that future population growth will occur along a north-south corridor between the Great Miami and the Little Miami Rivers.

Population projections are used as a base for calculating the anticipated quantities of sludge from each of the operating and proposed wastewater treatment facilities.

Population projections for the wastewater treatment plants through 1995 are shown in Table 5-5. Values provided by O-K-I for certain plants

Table 5-3. SOURCES OF WASTEWATER FOR OPERATING TREATMENT PLANTS

Plant	Average daily flow (mgd)	Source of wastewater		
		Domestic	Industrial	Domestic and industrial
1. Mill Creek	120			+
2. Little Miami	31			+
3. Bromley	20.8			+
4. Middletown	10			+
5. Franklin	9			+
6. Muddy Creek	8.3	+		
7. Hamilton	7			+
8. Sycamore	3.5	+		
9. Oxford	2.64	+		
10. Lawrenceburg	2.5[a]			+
	1.4[b]			+
11. Bethel	0.47	+		
12. New Richmond	0.10			+
13. Felicity	0.081	+		
14. Mayflower	0.035	+		
15. Systech	0.045		+	

[a] Plant No. 1.

[b] Plant No. 2.

Source: Personal contacts with Plant Operators.

Table 5-4. ANALYSIS OF SLUDGE FROM FRANKLIN WASTEWATER TREATMENT PLANT

Parameter	Concentration (mg/kg dry sludge)	Concentration (mg/l wet sludge)
Iron	16,820	1,178
Manganese	3,043	213
Copper	574	40
Zinc	1,321	93
Cadmium	247	17
Lead	1,005	70
Nickel	46	3
Mercury	156	11

Table 5-5. POPULATION PROJECTIONS FOR SAMPLE WASTEWATER TREATMENT FACILITIES[a,b]

Facility[c]	1977	1980	1985	1990	1995
1. Mill Creek	547,612	561,237	583,324	600,639	613,164
2. Little Miami	159,471	159,121	159,246	159,825	158,709
3. Bromley	Plant will be phased out.				
4. Middletown[d]	48,178	48,423	49,721	51,722	53,513
5. Franklin[d]	11,981	12,656	13,964	13,571	13,498
6. Muddy Creek	67,386	68,069	68,823	69,629	71,722
7. Hamilton	68,928	69,512	70,417	70,176	70,623
8. Sycamore	31,392	32,812	34,963	36,567	37,587
9. Oxford[d]	18,422	17,634	16,918	16,041	15,469
10. Lawrenceburg[d]	13,197	13,266	13,431	13,579	13,661
11. Bethel[d]	2,354	2,377	2,406	2,425	2,441
12. New Richmond[d]	2,024	1,898	1,753	1,666	1,598
13. Felicity	582	587	600	626	655
14. Mayflower	620	650	700	750	800
15. Systech	Serves industrial population only.				
Subtotal	972,147	988,242	1,016,266	1,037,216	1,053,440
16. Dry Creek	200,773	205,089	212,409	216,409	218,414
17. LeSourdsville	21,966	25,034	29,809	34,627	38,563
18. Cleves-North Bend	3,042	3,295	3,716	4,137	4,558
Subtotal	225,781	233,418	245,934	255,173	261,535
Grand Total	1,197,928	1,221,660	1,262,200	1,292,389	1,314,975

[a] Projections are for domestic population only.
[b] Population projections were derived using the method described in the text.
[c] Plant No. 1 thru 15 are operating; 16 thru 18 are proposed.
[d] Population projections provided by O-K-I.

Table 5-6. PROJECTED SLUDGE QUANTITES FOR SAMPLE PLANTS

	Facility[k]	1977	1980	1985	1990	1995
1	Mill Creek[a]	1369.00/54.76[j]	1403.00/56.12	1458.25/58.33	1501.50/60.06	1533.00/61.32
2	Little Miami[a]	398.75/15.95	397.75/15.91	398.00/15.92	399.50/15.98	396.75/15.87
3	Bromley	Plant will be phased out				
4	Middletown[a]	120.50/4.82	121.00/4.84	124.25/4.97	129.25/5.17	133.75/5.35
5	Franklin[b]	17.99/1.08	18.99/1.14	21.00/1.26	20.33/1.22	20.17/1.21
6	Muddy Creek[b]	168.50/6.74	170.25/6.81	172.00/6.88	174.00/6.96	179.25/7.17
7	Hamilton[a]	172.25/6.89	173.75/6.95	176.00/7.04	175.50/7.02	176.50/7.06
8	Sycamore[a]	78.50/3.14	82.00/3.28	87.50/3.50	91.50/3.66	94.00/3.76
9	Oxford[a]	30.67/1.84	29.33/1.76	28.33/1.70	26.67/1.60	25.83/1.55
10	Lawrenceburg[a]	33.00/1.32	33.25/1.33	33.50/1.34	34.00/1.36	34.25/1.37
11	Bethel[c]	5.60/0.28	5.80/0.29	5.80/0.29	5.80/0.29	5.80/0.29
12	New Richmond[d]	5.00/0.05	5.00/0.05	4.00/0.04	4.00/0.04	4.00/0.04
13	Felicity[e]	0.30/0.009	0.30/0.009	0.30/0.009	0.30/0.009	0.30/0.009
14	Mayflower[f]	12.00/0.12	12.00/0.12	13.00/0.13	14.00/0.14	15.00/0.15
15	Systech[i]	Sludge quantities contribute to Franklin facility totals				
	Subtotal	2412.06/97.00	2452.42/98.61	2521.93/101.41	2576.35/103.51	2618.60/105.15
16	Dry Creek[a]	501.75/20.07	512.72/20.51	531.10/21.24	541.02/21.64	546.03/21.84
17	LeSourdsville[g]	58.58/1.76	66.76/2.00	79.50/2.38	92.34/2.77	102.83/3.09
18	Cleves-North Bend[h]	11.41/0.46	12.36/0.49	13.94/0.56	15.51/0.62	17.09/0.68
	Subtotal	571.74/22.29	591.84/23.00	624.54/24.18	648.87/25.03	665.95/25.61
	Grand Total	2983.80/119.28	3044.26/121.61	3146.47/125.59	3225.22/128.54	3284.55/130.76

[a] Sludge production assumed at 0.20 lb/cap/d @ 4% solids.
[b] Sludge production assumed at 0.18 lb/cap/d @ 6% solids.
[c] Sludge production assumed at 0.24 lb/cap/d @ 5% solids.
[d] Sludge production assumed at 0.05 lb/cap/d @ 1% solids.
[e] Sludge production assumed at 0.03 lb/cap/d @ 3% solids.
[f] Sludge production assumed at 0.38 lb/cap/d @ 1% solids.
[g] Sludge production assumed at 0.16 lb/cap/d @ 3% solids.
[h] Sludge production assumed at 0.30 lb/cap/d @ 4% solids.
[i] Plant provides pretreatment to industrial wastewater.
[j] Values given in wet tons per day and dry tons per day. Values do not account for sludge production from Industrial Sectors.
[k] Plant No. 1 thru 15 are operating; 16 thru 18 are proposed.
ton x 0.908 = metric ton

(see footnote d of the table) are based on traffic zones and are believed to be more accurate than the other projections, which are derived from the drainage basin map and the population estimates given in Reference V-2.

5.3.1 Projected Sludge Quantities For O-K-I Projected Population

The Federal Water Pollution Control Act, amendments of 1972 require the application of the Best Practicable Treatment by July 1, 1977, and the utilization of the Best Available Treatment technology by July 1, 1983, by publicly owned treatment works. This will result in generation of larger quantities of sludge which will have to be processed and ultimately disposed.

The wastewater treatment facilities selected for the case studies could not provide detailed information on projected sludge quantities or anticipated wastewater flows in the year 1995 nor was this information available from the NPDES permits. The methodology is therefore used to develop projected sludge quantities. The quantities are calculated by applying factors from the methodology to the population projections in Table 5-5. Table 5-6 shows the projected sludge quantities as well as applicable factors for the sample plants.

Projected sludge quantities for the entire O-K-I region are shown in Table 5-7. These estimates do not account for the sludge generated by treatment of industrial wastes, since none of the sample plants could provide estimates of waste loads from the industrial sectors of the community.

Projection of future wastewater loads from industries would require knowledge of two factors:

Table 5-7. PROJECTED SLUDGE QUANTITIES FOR THE ENTIRE O-K-I AREA[a]

Year	Population[b]	Sludge quantity[c]
1977	1,769,742	3760.61/150.42
1980	1,827,390	3883.21/155.33
1985	1,928,320	4097.68/163.91
1990	2,015,940	4283.87/171.35
1995	2,094,760	4451.37/178.06

[a] It is assumed that 85% of the population shown will be serviced by sewer lines (Ref. V-3).

[b] Population estimates obtained from Ref. V-2.

[c] Sludge quantities are given in wet tons per day and dry tons per day. Sludge production assumed at 0.20 lb/cap/d @ 4% solids. (.09 kg/cap/d). Sludge production does not account for contribution of sludge from industrial wastewater sources.
ton x 0.908 = metric ton.

1. The types and sizes of industries that will operate in the region.
2. When the industries will start operating.

A requirement for pretreatment of industrial wastes in future years could significantly reduce the loadings and treatment upsets at municipal wastewater treatment plants. Within the O-K-I area, the pretreatment standards as promulgated on December 10, 1973 by the Federal EPA, are not yet enforced. According to the law, there exists a three year period from the date of promulgation to the time of actual enforcement (Ref. V-4). Even with such a requirement, however, the problem of industrial sludge disposal will persist. Whether the treatment takes place at the industrial site or at a municipal wastewater treatment plant, the quantity of sludge to dispose of will be the same.

REFERENCES

V-1 Municipal Sludge Management: Environmental Factors (Draft), U.S. Environmental Protection Agency, Washington, D.C. 20460. EPA 430/9-75-XXX.

V-2 Population Projections and Acreages by Drainage Area, Interim Report 1. O-K-I Regional Council of Governments. Cincinnati, Ohio. June 1975. (See Ref. III-1).

V-3 Personal Communications with Mike Smith of O-K-I, Cincinnati, Ohio, November, 1975.

V-4 40 CFR 128. November 8, 1973.

6.0 REGULATIONS AFFECTING SLUDGE MANAGEMENT

Regulations regarding air and water quality, land use, and solid waste disposal affect the selection of alternatives for sludge management. Inappropriate alternatives can be eliminated on the basis of legal restrictions. For this reason it is important that planners are aware of any changes in the applicable regulations.

6.1 WATER REGULATIONS

Since the O-K-I Region encompasses counties in three states, regulations pertaining to each state are applicable. Of particular interest are regulations that apply to the discharge of pollutants resulting from treatment and/or disposal of wastes from treatment facilities.

6.1.1 Ohio Regulations

Chapter 6111 of the Ohio Revised Code empowers the Director of Environmental Protection to develop plans; administer Federal and state grants; encourage studies, investigations, research, and demonstrations relating to water pollution; and adopt, modify, and repeal regulations in accordance with Chapter 119 of the Revised Code. The Director may also issue, revoke, modify, or deny permits for sewage, industrial waste, or other waste discharge into state water bodies in compliance with all requirements of the Federal Water Pollution Control Act Amendments of 1972 (FWPCA, PL 92-500), and subsequent regulatory provisions such as pretreatment standards as they are promulgated.

6.1.2 Kentucky Regulation

In Kentucky the Department for Natural Resources and the Environmental Protection, Bureau of Environmental Quality, Division of Water Quality administers regulations dealing with water quality. Requirements which effectuate Kentucky Revised Statutes (KRS) Chapter 224, permit authority for sewage systems, is 401 Kentucky Administrative Regulations (KAR) 5:005, permits of discharge sewage; industrial and other wastes, pursuant to KRS 13.082, 224.033 (17). Regulation 401 KAR 5:005 requires a permit prior to construction and operation of a sewage system and sets forth requirements for receiving a permit to construct and operate such a system. Other pertinent regulations include 401 KAR 5:035, use classification of waters; treatment requirements; while, compliance relates to KRS 224.020 and 224.060; pursuant to KRS 13.082 and 224.033(17). All of these regulations, are a reiteration of FWPCA, PL 92-500, and mandate that all persons discharging pollutants through point sources shall apply "best practical control technology" and "best available technology economically achievable." The regulation provides narrative water quality standards for all waters and sets forth a use classification scheme with numeric criteria for applicable waters. Although these regulations relate primarily to point sources, pollution from nonpoint sources is the most likely result of sludge disposal by application to land.

6.1.3 Indiana Regulations

The Indiana Stream Pollution Control Law, Indiana Code (IC) 1971, 13-1-3 (Chapter 214, Acts of 1943; amended by Chapter 132, Acts of 1945; and amended by Chapter 64, Acts of 1957), determines water quality control. The law creates the Stream Pollution Control Board of the State of Indiana. Board members are granted power to make determinations that prohibit pollution to any waters of the state. Regulation Stream Pollution Control-15 (SPC-15), which has been adopted and promulgated by the Stream Pollution Control Board, prescribes policy and procedures to be followed in issuance of construction, operation, and discharge permits under the Environmental Management Act, IC 1971, 13-7, as amended. Also it provides for issuance of discharge permits under the National Pollutant Discharge Elimination System program required by the Federal Water Pollution Control Act as amended. Official New Rule SPC 17 as adopted and promulgated by the Stream Pollution Control Board is pursuant to the authority of IC 1971, 13-7 as amended. Although the regulations refer primarily to point source discharges, planners should consider over-all water quality, and in particular any possible contamination of surface and groundwaters resulting from land disposal of sludge.

6.1.4 Water Quality Standards

The Ohio River forms the southern border of Ohio and Indiana and the northern border of Kentucky; it is the receiving water body for all tributaries in the O-K-I Region. By action of the ORSANCO Engineering Committee in September 1974, the Ohio River water quality criteria were updated. Limiting levels, concentration or intensity of key quality parameters established for intended water uses were later reflected in water quality standards promulgated by Ohio (EP-1) on January 10, 1975. Ohio and Indiana have EPA approved National Pollution Discharge Elimination System (NPDES) permit programs while Kentucky does not, so issuing authority still rests with Federal EPA Region IV. The water quality standards for issuing NPDES permits apply in most cases, to all warmwater streams in Indiana, Kentucky, and Ohio as listed in the following paragraphs; any differences in application are noted.

Dissolved Oxygen

Minimum daily average of 5.0 mg/l and no value less than 4.0 mg/l at any time.

Temperature

Maximum rise above natural temperature shall not exceed 5F (2.77C), allowable maximum temperatures during a month shall not exceed:

Month	Temperature		Month	Temperature	
	F	C		F	C
January	50	10.0	July	89	31.7
February	50	10.0	August	89	31.7
March	60	15.6	September	87	30.6
April	70	21.1	October	78	25.6
May	80	26.8	November	70	21.1
June	87	30.6	December	57	13.9

pH

No value below 6.0 nor above 8.5; high values due to photosynthetic activity may be tolerated.

> Ohio: values of 6.0 to 9.0 except values below 6.0 or more than 9.0 if there is no acidic or alkaline pollution attributable to human activities.
>
> Kentucky: values of 6.0 to 9.0

Bacteria--Total Coliform

Shall not exceed 5,000 per 100 ml as a monthly average value (either Most Probable Number (MPN) or Millipore Filter (MF) count), nor exceed this number in more than 20 percent of the samples examined during any month, nor exceed 20,000 per 100 ml in more than 5 percent of such samples.

Bacteria--Fecal Coliform

Content (either MPN or MF count) shall not exceed 200 per 100 ml as a monthly geometric mean based on not less than five samples per month; nor exceed 400 per 100 ml in more than 5 percent of such samples.

> Indiana: Public water supply - total coliform as above.
>
> Recreation: April through October: fecal coliform as above; November through March: fecal coliform content (either MPN or MF

count) shall not exceed 1,000 per 100 ml as a geometric mean based on not less than five samples; nor exceed 2,000 per 100 ml in more than one sample.

Kentucky: Public water supply - total coliform as above.

Recreation: total coliform level shall not exceed an average of 1,000 per 100 ml. Total coliform shall not exceed this number in 20 percent of the samples in a month, not exceed 2,400/100 ml on any day. If the total coliform level is exceeded, then a fecal coliform standard shall be used. There shall be a reduction of fecal coliform to such degree that (1) during the months of May through October fecal coliform density in the discharge does not exceed 200 per 100 as a monthly geometric mean (based on not less than ten samples per month), nor exceed 400 per 100 in more than ten percent of the samples examined during a month, and (2) during the months of November through April the density does not exceed 1,000 per 100 ml as a monthly geometric mean (based on not less than ten samples per month), nor exceed 2,000 per 100 ml in more than ten percent of the samples during the month.

Dissolved Solids

Not to exceed 500 mg/l as a monthly average value, nor exceed 750 mg/l at any time. (Equivalent 25C specific conductance values are 800 and 1,200 micromhos/cm).

Ohio: may exceed one, but not both of the following:

a. 500 mg/l as a monthly average nor exceed 750 mg/l at any one time, or,

b. 150 mg/l of dissolved solids attributable to human activities indicated at point of municipal discharge.

Chemical Constituents

The following are some of the limiting values for individual chemical constituents adopted by Indiana, Kentucky, and Ohio.

Constituents (mg/l)	Indiana	Kentucky	Ohio
Cadmium	0.01	0.01	0.005
Chromium (Hexavalent)	0.05	0.05	0.05
Copper	-	-	0.05
Fluoride	1.0	1.0	1.3
Lead	0.05	0.05	0.04
Mercury	-	-	0.0005
Zinc	-	-	1.0

6.1.5 Solid and Liquid Waste Management

Maintaining water quality criteria requires control not only of point sources but also of nonpoint sources, such as surfaces subject to runoff and erosion. Sludge disposal by landfilling and landspreading can create significant nonpoint sources. Contamination of surface and groundwaters is likely if the disposal site is poorly located or inadequately prepared. An undetermined number of area sources are also unregulated. Because disposal of liquid and solid wastes entails potential major area sources, all three states regulate waste disposal.

6.1.5.1 Solid Waste Disposal Regulations In Kentucky - Solid waste disposal in Kentucky is regulated by Kentucky Solid Waste Regulations 401 KAR 2:010 Solid Waste, Relates to KRS Chapter 224, Pursuant to KRS 13.082 and 224.033(17).

The Department for Natural Resources and Environmental Protection enforces the regulation through permitted sanitary landfills and inspections. Sanitary landfills are solid waste disposal sites or facilities at which putrescible and other solid wastes may be disposed. The regulations define solid waste to include garbage, rubbish, ashes, incinerator residue, street refuse, dead animals, demolition wastes, and special wastes including explosives, pathological wastes, and radioactive materials. This definition is broad enough to include wastewater sludges in any form including ash from incineration.

The regulations provide for protection of ground and surface water through directed drainage, dikes, impoundment, slope grading, and site selection. Site selection must take into account attenuating soils, geology, and observation of ground water levels. Sanitary landfills are prohibited in flood-prone areas.

6.1.5.2 Solid Waste Disposal Regulations in Ohio - In Ohio solid waste and sludge disposal is regulated under EP-20 Sanitary Landfill Standards and HE-24-01 to HE-24-12 inclusive of the Ohio Sanitary Code. Disposal of sewage solids and liquids at sanitary landfills is limited and must be segregated from areas used principally for the disposal of solid wastes resulting from community operation [EP-20-09 (H) (HE-24-09)].

Incinerators of solid waste including sludges must be operated so that the resulting residue will be substantially free of organic and putrescible material and that pollution of the air will not exceed the air quality standards established for the area by the air pollution control board pursuant to Section 3704.03 of the Revised Code [EP-20-10 (C) (HE-24-10)]. This requirement can be met in the O-K-I region. Regulations also provide for the protection of ground and surface waters in selection and operation of sanitary landfills.

6.1.5.3 Solid Waste Disposal Regulations in Indiana - Solid waste disposal in Indiana is regulated by Indiana Stream Pollution Control Board, Regulation SPC 18. This regulation prescribes the policy and procedures to be followed in connection with issuance of construction and operating permits under the Refuse Disposal Act, IC 1971, 19-21, as amended by Public Law 148, Acts of 1972; and as provided by the Environmental Management Act, IC 1971, 13-7. Indiana classifies sludges of less than 30 percent solids as hazardous wastes. Under no circumstances shall hazardous wastes be accepted at a sanitary landfill unless authorized in writing by the Board as its designated solid waste management agent.

Indiana also specifically controls pollution resulting from sanitary landfilling. For example, the law requires investigation of geological factors, soils, and ground and surface waters before permits are granted for construction and operation of a sanitary landfill. The Board also reserves the right to require monitoring wells. Surface water courses and runoff must be diverted from the sanitary landfill by trenches and proper grading. Open burning of solid wastes at a landfill or elsewhere is prohibited.

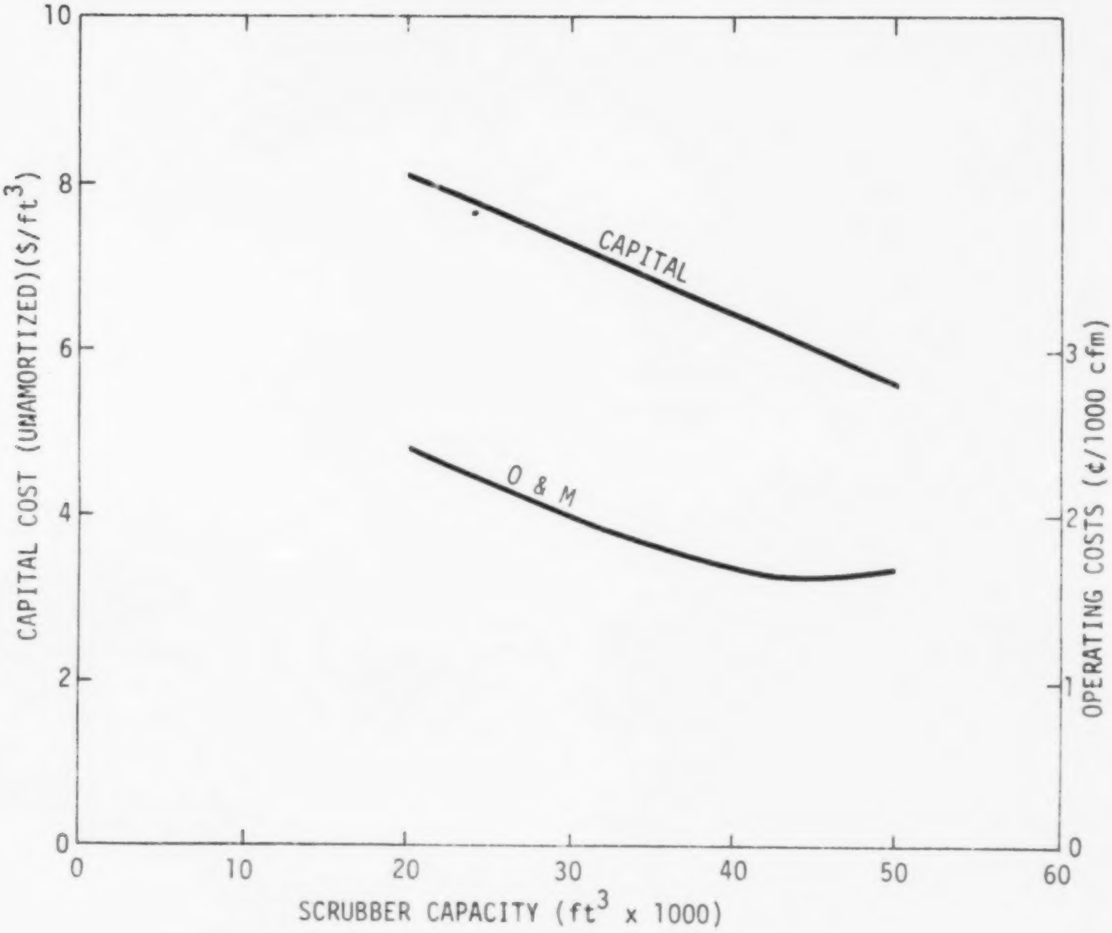
6.2 AIR QUALITY CONSIDERATIONS

The use of incineration as a means of sludge disposal could introduce new sources of air pollution into the Metropolitan Cincinnati Interstate Air Quality Control Region (AQCR 79). Construction of a new source or modification of an existing source that would result in the emission of air pollutants into the ambient air requires control of that source to meet the appropriate state and Federal regulations presented in Appendix C.

Wet scrubbing is considered the most effective and economical means of controlling emissions from sludge incineration. Figure 6-1 shows the capital and operating costs for venturi scrubber. The venturi scrubber has been installed on several sewage sludge incinerators and has achieved particulate removal efficiencies ranging from 98.3 to 99+ percent.

Emission tests of sewage sludge incinerators equipped with venturi scrubbers yield values ranging from 0.26 to 0.63 pound of particulate emissions per ton of dry sludge charged. Thus this equipment easily meets the Federal new source performance standard of 1.30 pounds of particulate emissions per ton of dry sludge charged. Furthermore, among the units tested plumes did not exceed 20 percent opacity, which is the second requirement of the Federal new source performance standard.

Although the Federal new source performance standard for sewage treatment plant incinerators does not regulate sulfur dioxide emissions, the State of Ohio proposes that sulfur dioxide emissions be limited by the following equation:



1. Electricity rate = 30 mills/kWh.
2. Water rate = \$0.20/1,000 gal.
3. Man hour rate = \$8.00/man hour
4. Pressure drop = 6 inches
5. Total hours of operation at full capacity = 6,000/yr

Figure 6-1. Capital and O&M Cost for venturi scrubber.
Source: Ref. VI-1.

$$E = 19.5\ P^{0.67}$$

Where E is the allowable emission in pounds of SO_2 per hour and P is tons of wet sludge charged per hour. New SO_2 limitations are under review by the Ohio EPA Director. Operators of sewage sludge incinerators in AQCR 79 should encounter no difficulty in complying with this current limitation without adding special equipment.

Three plants in AQCR 79 use sludge incineration, all in compliance with the air pollution control regulations. These plants could increase sludge handling to their rated capacities, and maintain the current scrubber efficiencies.

Combined capacity of the Muddy Creek, Middletown, and Millcreek plants is 1052 tons per day of wet filter cake. Projection for the O-K-I area for 1995 is 594 tons per day of wet filter cake for disposal. Therefore, since these three plants have the capacity for handling the projected sludge quantities, no further construction is needed. Total pollutants generated at these three plants would be 6.232 lb/hr of particulate, and 24.75 lb/hr of SO_2. The Ohio Emission Limitations for this rated capacity are 1397.8 pounds per hour of particulate, and 1570 pounds per hour of SO_2. Although the capacity of these three plants for handling projected sludge is adequate, an alternative regional possibility for the future would be to construct one sludge incinerator with a capacity exceeding 594 tons per day of wet sludge to serve the entire area. This alternative is examined in Section 8.

If such a regional plant were located in Kentucky, the applicable emission standard would be the Federal new source performance standard of 1.35 pounds of particulate per ton of dry sludge charged. Meeting this standard would necessitate the installation of a scrubber with 96.04 percent efficiency. Kentucky has no SO_2 regulation that affects sewage sludge incineration. If the plant were located in Ohio, it would have to comply with the Federal new source performance standards and also with the proposed Ohio SO_2 regulation covering sludge incineration. Controlled emissions from a possible new plant are projected to be 24.75 lb/hr of SO_2, and 99.99 lb/hr of particulate sludge generation in the O-K-I Area in 1995. Therefore incineration is feasible and emission standards can be met.

6.3 REGULATIONS RELATING TO LAND USE

Regulations governing land use in the O-K-I region are not coordinated among the three states or even among the counties and townships within each state. Each of the two Indiana counties does have a zoning ordinance that regulates land use within the county. Sludge disposal is permitted in areas zoned agricultural if it is beneficial to county residents.

In the Ohio and Kentucky portions of the region, however, individual townships regulate zoning, with varying degrees of effectiveness. Since the townships are based more on political than on geographical factors, the land-use regulations often differ significantly without apparent reason. In Clermont County, for example, most townships disallow sanitary landfills and make no alternative provision for disposal of residual wastes. Development of an effective sludge disposal system within the O-K-I region will require coordination of the land-use laws among the region's several jurisdictions. This is possible if each jurisdiction mutually agrees under each states interlocal cooperation provisions as sited in Section 8.

REFERENCES

VI-1 PEDCo-Environmental Specialists, Inc., Company Files. December 1975.

7.0 ALTERNATIVE SLUDGE MANAGEMENT METHODS

Methods for the ultimate disposal of residual wastes include sanitary landfilling, land reclamation, sludge recycling, ocean disposal, ponding, and resource recovery. Each of these methods has advantages and disadvantages. For example, direct disposal of raw sludge into the ocean may cause serious health hazards and may interfere with the natural aquatic life cycle. However, wastewater sludges may be valuable as fertilizer supplements and soil conditioners and can be utilized to reclaim sandy soils and strip mine spoils by converting them into valuable crop land or recreation areas.

In this application of the methodology, the sludge management alternatives are considered for each of the wastewater treatment facilities. Some can be eliminated at the outset because they are not applicable to the O-K-I region.

7.1 SLUDGE DISPOSAL PRACTICES

Many waste treatment plants dispose of sludge by the lowest-cost methods possible, with little regard to potential hazards to the environment. Examples are disposal on municipal sites, which are often dumps; on floodplains without covering; and on farms without precautions for protection of livestock. Although digested or semidigested sludge is often disposed of as if it were a completely innocuous material, even well-digested sludge contains pathogens, intestinal parasites, and possibly hazardous chemicals. Similarly, industrial waste sludges are often disposed of without sufficient regard for their toxic properties.

Disposal of sludges by methods that are both economically feasible and environmentally protective requires careful consideration of the available alternatives. Selection usually is based on employing the least costly of the methods that are environmentally safe. Other factors, however, such as the life of the site, secondary environmental aspects (e.g., noise from trucking), and projected uses of the disposal site should also be considered.

Following are the basic criteria for selection of an ultimate disposal method: (1) the method must be in accordance with local, state, and Federal water quality regulations; (2) the method should not cause significant degradation of surface or ground water, air, or land surfaces; (3) no sludge residues, grit, ash, or other solids should be discharged into receiving waters or plant effluents; and (4) sludge must be stabilized prior to spreading on land.

The numerous methods used for sludge disposal in the study area are summarized in Table 7-1. Of the 15 plants now operating, eight use incineration, three use wet landspreading, (application of liquid sludge on land), two use dry land spreading of dewatered sludge, (application of dried treated sludge on land), one uses landfilling, and one uses various methods at different times. For the three proposed plants, also, incineration and land spreading are the most popular disposal alternatives. Interestingly, all the plants located in large urban areas use incineration, whereas the plants located in small urban areas surrounded by rural areas use land spreading. Because facilities do not maintain records of costs for disposal of sludge, an economic evaluation is not readily available. Wherein possible, the methodology was used to generate such cost information.

There are approximately 23 sanitary landfills in the O-K-I area (Figure 7-1). Although some of these sites are small, most are large enough to handle dewatered sludge which can be mixed with household refuse or construction site debris. Appendix D lists the 23 sanitary landfills. All of the landfill sites are licensed by the respective state agencies.

7.2 APPLICATION OF THE METHODOLOGY

The methodology was developed as a guide to 208 Planning Agencies in evaluating alternatives for the ultimate disposal of wastewater treatment residuals. It is intended for application to plants now operating as well as to those proposed for the future. In each case the planners must consider physical, technological, environmental, economical, social, and institutional constraints.

Applying the methodology to the O-K-I region involves two basic steps: (1) projecting sludge quantities in the study area and (2) developing feasible and acceptable sludge management alternatives. For projection of sludge quantities, information on the anticipated wastewater flows in 1995 at each facility is incomplete. Therefore, an average factor of 0.20 lb/cap/day (0.08 kg/cap/day) as shown in the methodology is used in calculations, including those for typical costs of feasible sludge management alternatives.

During the course of this demonstration, several advantages and constraints to application of the methodology have been recognized.

7.2.1 Advantages

(1) The methodology is particularly useful in showing decision-making pathways toward sludge management alternatives.

(2) It compiles current technological data useful not only to plant operators but also to practicing engineers and planners.

Table 7-1. PRESENT ULTIMATE DISPOSAL PRACTICES AT SAMPLE PLANTS

Wastewater treatment facility	Ultimate disposal practice
1. Mill Creek	Incineration, Ash to Ash Lagoon
2. Little Miami	Incineration, Ash to Ash Lagoon
3. Bromley	Incineration, Ash to Ohio River
4. Middletown	Incineration, Ash to Ash Lagoon
5. Franklin	Land spreading (Wet - Primary Industrial Sludge) Incineration (Primary Domestic Sludge)
6. Muddy Creek	Incineration, Ash to Ash Lagoon
7. Hamilton	Landfilling (Mixed with Construction Debris)
8. Sycamore	Incineration, Ash to Ash Lagoon
9. Oxford	Land spreading (Wet)
10. Lawrenceburg	Land spreading (Dry)
11. Bethel	(Various)
12. New Richmond	Land spreading (Dry)
13. Felicity	Land spreading (Wet)
14. Mayflower	Incineration, Ash to Ash Lagoon
15. Systech	(Not applicable)[a]
16. Dry Creek	Incineration, Ash to Landfill
17. LeSourdsville	Land spreading (Wet)
18. Cleves-North Bend	Landfilling

[a] Systech pretreats industrial liquid wastes. The effluent from the plant is pumped to the Franklin WTP for further treatment.

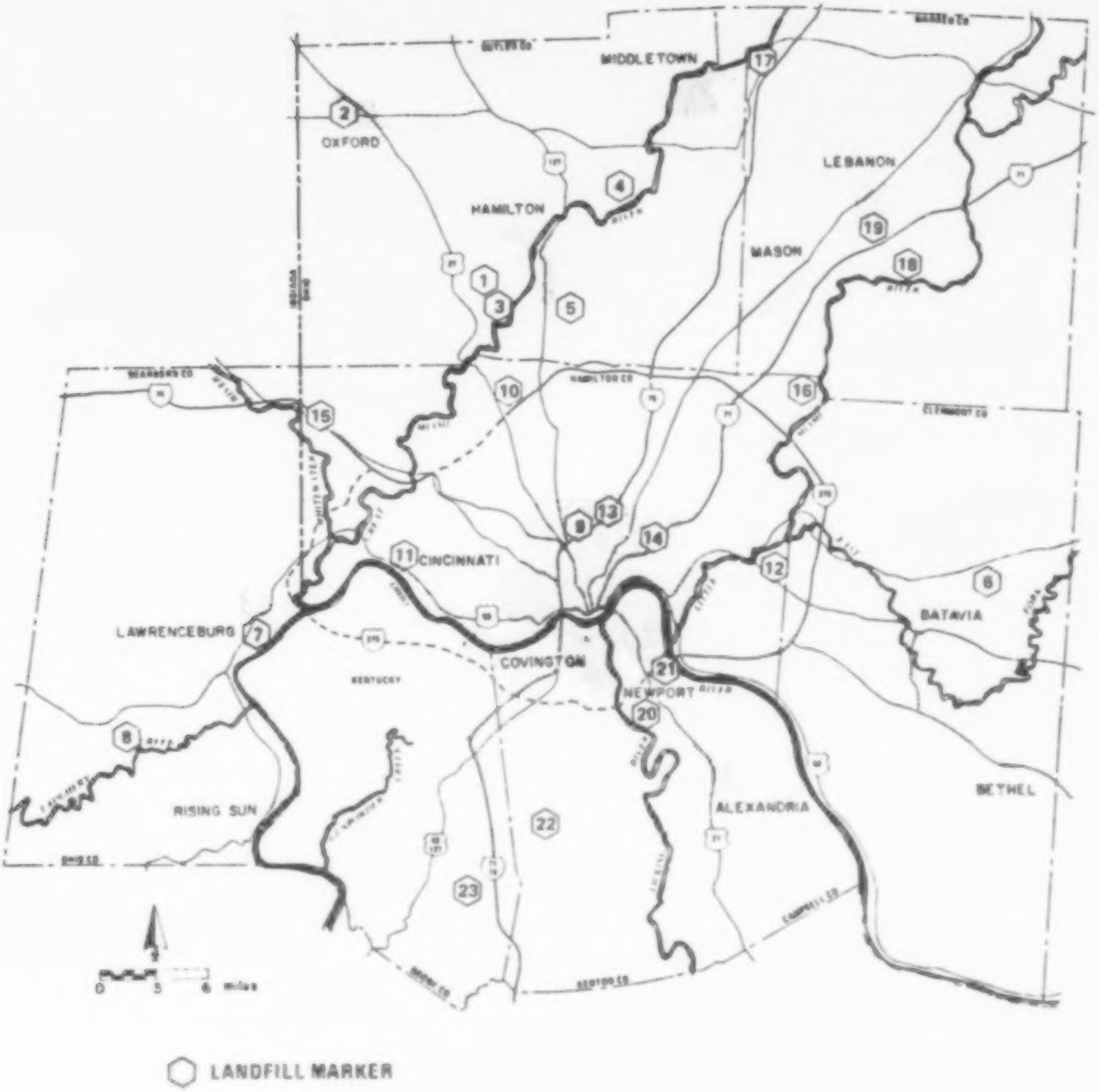


Figure 7-1. Sanitary landfills in the O-K-I area.

(3) It documents typical cost data that are useful, as in this demonstration study, when actual costs are not available.

(4) The methodology demonstrates that pipe transport of digested sludge (3.5 percent solids) is not economically feasible when daily throughputs are low.

7.2.2 Constraints

(1) As in all 'model' or 'typical' applications, care must be exercised in applying the methodology's typical cost data to a specific plant operation. A presentation of the data base used to derive these costs could provide the planner with a rationale for developing site-specific estimates.

(2) With respect to interpretation of data requiring scalar modification or extrapolation, the methodology provides no reference points. For example, costs are given for land spreading of sludge with 3.5 percent solids. The planners should know what contributes to these costs and how to extrapolate for sludges of different solids content.

(3) Cost analysis in the methodology should be extended to include costs of hauling dewatered sludge (25 to 40 percent solids) by truck and costs of dry land spreading by various means.

7.3 ELIMINATED ALTERNATIVES

All of the alternatives for sludge dipsosal that are described in the methodology were evaluated for possible application to each of the 15 operating and the three proposed plants. Evaluation was based on several criteria, including economic feasibility, environmental impacts, public acceptance and technical effectiveness. If in any case a disposal alternative did not meet the criteria, it was not considered further for application to the plant in question.

Several alternatives were eliminated on a regional basis before scenarios for each plant were developed. Ocean disposal was not considered since the geographic location of the study area precludes this possibility. (Disposal in ocean waters is not generally recommended in any case.) Pyrolysis was not considered practicable in the O-K-I area for several reasons. Since pyrolysis technology is relatively new, and its application to wastewater sewage sludge is even more recent, test data with which to evaluate its applicability to the O-K-I region are not yet available. Pyrolysis remains, however, a possible alternative for future application. Recalcination was eliminated as a resource recovery alternative for the O-K-I region, since no treatment plants in the area use lime in sufficient quantities to make the method feasible. Disposal ponds, although not eliminated, were seldom considered because of the characteristically objectional odors associated with disposal ponds and the difficulty in sealing or lining them. Land reclamation was considered for a regional consolidation of sludges rather than for individual plants. The only site for reclamation is some 250 miles from the study area; therefore on an individual plant basis the transportation costs and limited sludge quantities disfavour this alternative.

7.4 ALTERNATIVES SELECTED FOR APPLICATION

Alternatives selected for application in the study area are land spreading (wet and dry), landfilling, incineration, and ponding. Effort was made first to investigate those alternatives that offer possible utilization benefits as a result of the existing method of disposal. Because of the relatively large outlying rural areas in O-K-I, land spreading is often considered a possible alternative. In each case, however, possible effects of environmental parameters such as soils, hydrology, and topography are also considered. Landfilling, ponding, and incineration, also considered for each plant, offer no utilization benefits.

8.0 FEASIBLE SLUDGE MANAGEMENT ALTERNATIVES

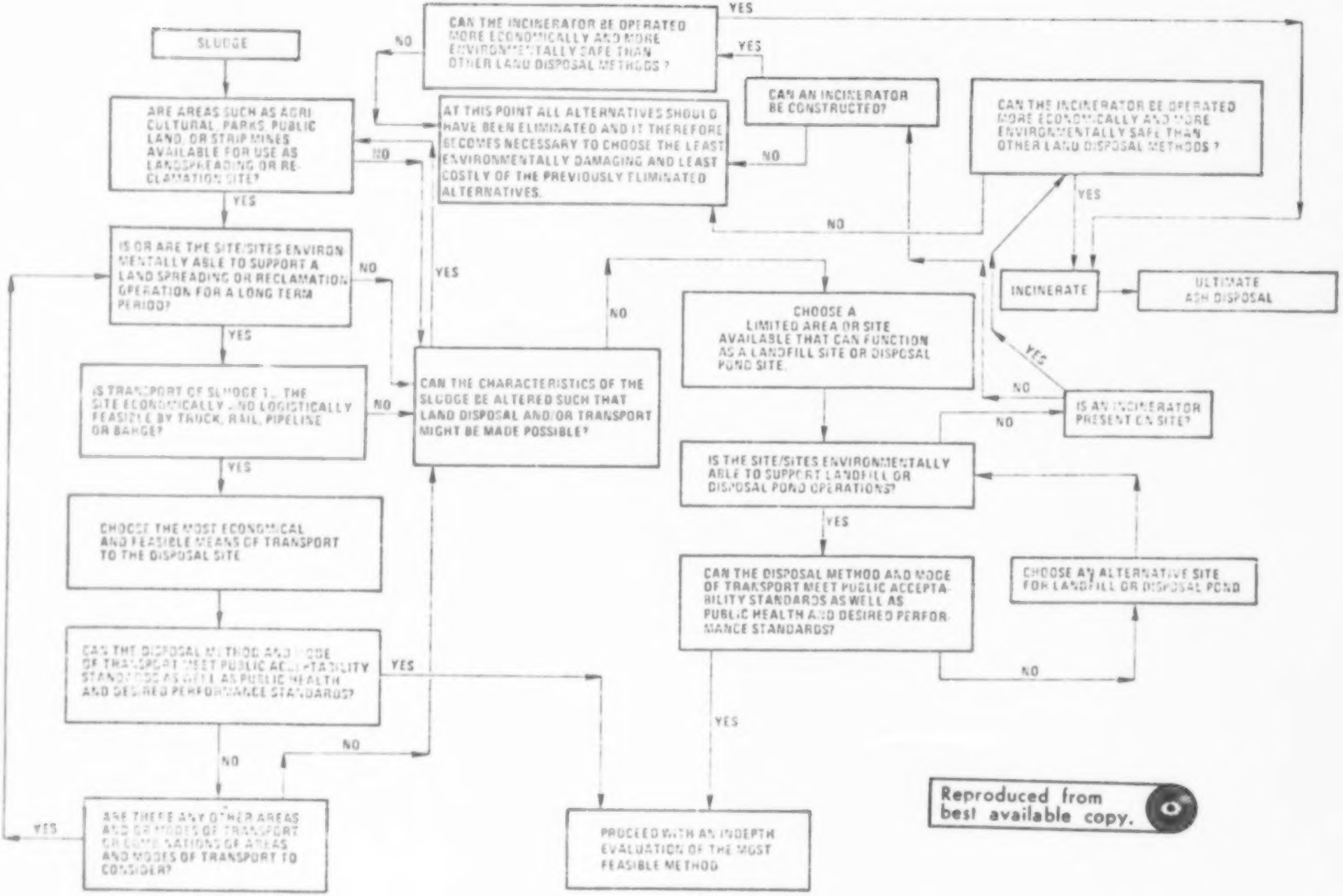
Application of the methodology in the O-K-I region must be done on a trial and error basis through successive iterations until a satisfactory alternative can be selected. As discussed in Section 7, certain possible alternatives are eliminated as infeasible in the O-K-I region (e.g. ocean dumping) and others are considered on a regional scale rather than for application to individual plants (e.g. land reclamation). Disposal methods now practiced satisfactorily at the treatment plants are considered as alternatives for the future, along with other methods.

Figure 8-1, a modification of Figure VII-1 in the methodology, delineates pathways used in testing various approaches to a "best" sludge managment alternative under varying conditions. Each disposal alternative, such as land spreading, is tested under a uniform set of conditions for each plant.

As an aid in applying the methodology consistently in this analysis of the O-K-I region, the following set of definitions and assumptions was developed:

DEFINITIONS AND ASSUMPTIONS

1. 'Raw sludge' is defined as the material that settles out in the primary settling tanks (clarifiers). Solids content in raw sludge is 4 to 6 percent.
2. 'Waste activated sludge' is the sludge that settles in the secondary settling tank (clarifier), that is not recycled to the aeration tanks. Solids content is 1 to 3 percent.
3. 'Combined wet sludge' denotes the summation of raw sludge and waste activated sludge. Solids content is 4 to 6 percent.
4. 'Dewatered sludge' is any sludge that has passed through a dewatering step, e.g. vacuum filtration or centrifugation.
5. 'Filter cake' refers specifically to the wet cake that is dropped off a rotary vacuum filter. Solids content is 20 to 30 percent.


SLUDGE
ARE AREAS SUCH AS AGRICULTURAL, PARKS, PUBLIC LAND, OR STRIP MINES AVAILABLE FOR USE AS LANDSPREADING OR RECLAMATION SITE?
YES
NO
IS OR ARE THE SITE/SITES ENVIRONMENTALLY ABLE TO SUPPORT A LAND SPREADING OR RECLAMATION OPERATION FOR A LONG TERM PERIOD?
YES
NO
IS TRANSPORT OF SLUDGE TO THE SITE ECONOMICALLY AND LOGISTICALLY FEASIBLE BY TRUCK, RAIL, PIPELINE OR BARGE?
YES
NO
CHOOSE THE MOST ECONOMICAL AND FEASIBLE MEANS OF TRANSPORT TO THE DISPOSAL SITE
CAN THE DISPOSAL METHOD AND MODE OF TRANSPORT MEET PUBLIC ACCEPTABILITY STANDARDS AS WELL AS PUBLIC HEALTH AND DESIRED PERFORMANCE STANDARDS?
YES
NO
ARE THERE ANY OTHER AREAS AND OR MODES OF TRANSPORT OR COMBINATIONS OF AREAS AND MODES OF TRANSPORT TO CONSIDER?
YES
NO
CAN THE INCINERATOR BE OPERATED MORE ECONOMICALLY AND MORE ENVIRONMENTALLY SAFE THAN OTHER LAND DISPOSAL METHODS ?
YES
NO
AT THIS POINT ALL ALTERNATIVES SHOULD HAVE BEEN ELIMINATED AND IT THEREFORE BECOMES NECESSARY TO CHOOSE THE LEAST ENVIRONMENTALLY DAMAGING AND LEAST COSTLY OF THE PREVIOUSLY ELIMINATED ALTERNATIVES.
YES
CAN THE CHARACTERISTICS OF THE SLUDGE BE ALTERED SUCH THAT LAND DISPOSAL AND/OR TRANSPORT MIGHT BE MADE POSSIBLE?
NO
CAN AN INCINERATOR BE CONSTRUCTED?
YES
NO
CAN THE INCINERATOR BE OPERATED MORE ECONOMICALLY AND MORE ENVIRONMENTALLY SAFE THAN OTHER LAND DISPOSAL METHODS ?
YES
NO
INCINERATE
ULTIMATE ASH DISPOSAL
CHOOSE A LIMITED AREA OR SITE AVAILABLE THAT CAN FUNCTION AS A LANDFILL SITE OR DISPOSAL POND SITE.
IS AN INCINERATOR PRESENT ON SITE?
YES
NO
NO
IS THE SITE/SITES ENVIRONMENTALLY ABLE TO SUPPORT LANDFILL OR DISPOSAL POND OPERATIONS?
YES
CAN THE DISPOSAL METHOD AND MODE OF TRANSPORT MEET PUBLIC ACCEPTABILITY STANDARDS AS WELL AS PUBLIC HEALTH AND DESIRED PERFORMANCE STANDARDS?
YES
NO
CHOOSE AN ALTERNATIVE SITE FOR LANDFILL OR DISPOSAL POND
PROCEED WITH AN INDEPTH EVALUATION OF THE MOST FEASIBLE METHOD

Reproduced from best available copy.

Figure 8-1. Decision network.

6. 'Incinerator feed' in most instances is the 20 to 30 percent solids filter cake defined in 5.

7. 'Ash' is the residual solid material resulting from incineration of the filter cake. Most of the ash is slurried and disposed of in lagoons. Slurried ash is assumed to be 7.5 percent solids.

8. 'Secondary sludge' refers to the sludge settled out in a secondary clarifier or in settling tanks.

9. 'Digested sludge' refers to the sludge that is aerobically or anaerobically digested.

10. 'WTP' denotes wastewater treatment plant.

11. 'Wet land spreading' for the purpose of this report refers to the application of liquid sludge or slurried ash (1 to 9% solids) on rural or agricultural land.

12. 'Dry land spreading' for the purpose of this report refers to the application of dewatered sludge (15 to 45% solids) on rural or agricultural land.

13. In the context of developing alternatives, 'navigable stream' is defined as one in which large sludge barges could safely negotiate; it is not used in the legal sense.

14. Information and quantities presented are based on data received from the wastewater treatment plants. Where data were not provided, typical data described in the methodology are used, and appropriately referenced in the text.

15. The methodology was used to generate capital costs and O&M costs for the WTP process equipment; the exception to this is the Cleves-North Bend and the LeSourdsville wastewater treatment plants (proposed) which supplied specific design data costs.

16. In general, data obtained from the individual treatment facilities are converted from gallons to tons according to the following formula:

    Tons = (gallons x 8.34 pounds per gallon)/2000 pounds per ton

17. Unless otherwise stated, all sludge quantities are calculated on a wet ton basis.

18. No recommendations are made specifically for disposal of sludge during inclement or winter weather; this remains a matter of individual plant operation. However, recommendations were made for the disposal of sludge during inclement weather for regional alternatives.

19. Quantities of aerobic or anaerobically digested sludge suitable for wet land spreading could not be calculated when not included in WTP data since the overall plant material balances were not that precise.

20. Haulaways of sludges are calculated in wet tons per day.

21. Truck transportation costs in all cases are based on round trip travel distance.

22. Pipe transportation of sludge in most cases is uneconomical because it involves low throughputs, high construction costs in urban areas, and limited distribution flexibility.

23. For the purpose of this report, it is assumed that vacuum filter operation involves no solids removal in the filtrate stream, i.e. 100 percent capture is assumed. In reality the capture rate is only 90 to 95 percent.

24. Wet land spreading would be done by use of farm equipment, by spraying, or by soil injection. Typical costs are based on a composite of these three means of application.

25. For wet or dry land spreading, land would be bought, leased, or contracted for with the land owners. Although local governments acting jointly or individually have power of eminent domain and may take land for a public purpose, this is not considered as an immediate practical step, but rather as a last resort.

26. 'Processing equipment' refers to the unit processes (e.g., gravity thickening, anaerobic digestion, incineration, etc.) used in the treatment of sludge, prior to transport and ultimate disposal. The applicable unit processes for each plant for which capital and O&M costs are calculated are shown in Table 8-1 at the end of Section 8.17.

27. All costs represent mid-1975 costs. An interest rate of 8 percent calculated over a 20 year ammortization period of level debt service is assumed. The 8 percent interest rate reflects current interest rates.

28. Capital costs for unit processes are referenced to an Engineering News Record (ENR) Construction Cost Index of 2200, representing mid-1975 costs. The unit prices include basic manufacturing and installation costs, contractor's profit, and a 25 percent allowance for engineering, legal costs, and contingencies. Not included in the prices are the costs of land or the acquisition of rights-of-ways.

29. The operation and maintenance costs for the unit processes are related to the average daily weight of dry solids processed. Materials incorporated in the costs typically include expendable materials, chemicals, power for pump and blowers, etc. Labor costs were based on an average hourly wage rate of $4.00 with 25 percent additional fringe benefits. Costs of materials were adjusted to a Wholesale Price Index for Industrial Commodities of 150. Operating labor is used for equipment start-up, sampling analyses, monitoring, control and shut down. Maintenance labor is required for cleaning and repair of process equipment.

30. If the alternative for centralized dewatering facilities at the four suggested regionalized transfer areas within O-K-I area is selected, these facilities will generate a filtrate that can be treated in small, on-site package plants prior to chlorination and discharged to a nearby stream. Filtrate could also possibly be discharged to existing sewer systems.

Table 8-1 at the end of this section summarizes cost of selected alternatives for each of the 15 sampled wastewater treatment plants and 3 proposed plants in the O-K-I region. In addition Table 8-9 summarizes costs of four regional alternatives.

*Table 8-1 illustrates that excess costs may result in employing anaerobic digestion along with incineration. Therefore, future design and provision of facilities should involve a more careful consideration for omitting one or the other process. Although the largest initial capital cost and annual costs are associated with digestion, a detailed engineering and cost investigation would be necessary to determine a correct approach. Moreover, existing capitalized equipment in operating plants need not be a constraint to improve management. For example, decommissioning of unnecessary equipment may provide savings of O&M costs.

Scenarios describing selection of sludge management alternatives for each plant are presented in the following sections. For application on an O-K-I regional basis, four alternatives are presented: central landfill, barging down the Ohio River, central land spreading and central incineration. Suggested region-wide institutional and financing arrangements are also presented for consideration.

8.1 MILL CREEK WASTEWATER TREATMENT PLANT

Influent rate at the Mill Creek WTP is 120 mgd (456,000 m^3/d). Evaluations are based on daily generation of the following types and quantities of sludge and residuals (see Appendix B):

Sludge type or Residual	Quantity tons(metric tons)/d	Percent solids
Raw sludge	1987(1804)	5.0
Anaerobically digested sludge	455(413)	9.1
Filter cake	124(113)	33.0
Ash from Incineration:		
Dry basis	23(21)	100
Wet basis (slurried with scrubber water)	307(279)	7.5

Dry land spreading and landfilling of ash are not considered suitable for the Mill Creek WTP since ash is slurried with the incinerator scrubber water prior to discharge. Ponding of the anaerobically digested sludge is not practicable because Hamilton County has very little undeveloped area suitable for such purposes.

The Mill Creek WTP now practices anaerobic digestion, vacuum filtration, and incineration with subsequent disposal of incinerator ash to lagoons; all of these have applicability for future operation of the plant.

8.1.1 Land Spreading (Wet)

The nearest rural area suitable for spreading of either anaerobically digested sludge or slurried ash is about 25 miles (40 km) west of the plant in Dearborn County, Indiana. Since there is no rail service and no navigable waterway from the treatment plant to this area, transport must be by pipeline or truck. Calculations indicate that trucking is more economical than piping because of the long distances and steep slopes, as well as the associated pumping costs.

Soils in most northern portions of Dearborn County are acceptable for land spreading. Seasonal high water tables and flooding pose no threat. Although slopes are steep in places, many possible sites with gentler slopes might be available. Except for areas near the Whitewater River, there is little possibility of contaminating groundwater within the Dearborn County region.

Truck transport over 50 miles (80 km) round trip distance is estimated to be \$2.20 per wet ton (\$2.42/metric ton) of either anaerobically digested sludge or slurried ash (Ref. VIII-4). Costs of wet land spreading of either type of sludge is estimated to be \$1.08 per wet ton (\$1.19/metric ton) (Ref. VIII-4). Total cost of transport and land spreading therefore is \$3.28 per wet ton (\$3.61/metric ton).

The Mill Creek WTP generates 455 wet tons (413 metric tons) of anaerobically digested sludge per day; costs of land spreading of this material are calculated as follows:

(455 wet tons/day) x (\$3.28/wet ton) x (365 days/year)

= \$544,726 per year

Of this total, \$221,000 is annual amortized capital cost and \$324,726 O&M. Applying the methodology to the existing WTP process equipment would add annual amortized capital costs of \$602,200 and \$92,000 O&M.

Analogously, wet land spreading of the ash slurry in quantities of 307 wet tons (279 metric tons) per day would cost \$367,540 per year. Of this total \$149,000 is annual amortized capital costand \$218,540 O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of \$1,083,300 and O&M of \$331,000.

Though the ash slurry is suitable for wet land spreading, it has little fertilizer value aside from its mineral content. Its value for strictly agricultural applications is limited unless something like urea is added as a supplementary fertilizer.

8.1.2 Land Spreading (Dry)

The plant produces approximately 124 wet tons (113 metric tons) of filter cake per day. The filter cake could be land spread in the same area as the digested sludge. The cost of transporting the filter cake by truck would be \$2.75 per wet ton (\$3.03/metric ton) (Ref. VIII-5). Spreading costs are estimated at \$1.24 per wet ton (\$1.37/metric ton) of filter cake (Ref. VIII-10,11). Total cost for transport and dry land spreading is \$3.99 per wet ton (\$4.40/metric ton) of filter cake. Total annual cost of transport and disposal is \$180,600 of which \$65,500 is amortized capital cost and \$115,100 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of \$813,000 and O&M of \$250,000.

8.1.3 Landfilling

Landfilling can be considered an ultimate disposal method only when the sludge has been dewatered. The total quantity of filter cake that would have to be landfilled is 124 wet tons (113 metric tons) per day. The nearest landfill that could accept the sludge cake is located about 20 round trip miles (32 km) from the plant on Este Avenue in Cincinnati.

The only feasible means of transporting the sludge cake to the landfill would be by truck since there are no rail services or navigable waterways, and filter cake is not readily suitable for piping. The cost of truck transport would be $1.45 per wet ton ($1.60/metric ton) (Ref. VIII-5). Cost of landfilling is estimated to be $12 to $15 per wet ton ($13.21 to $16.52 per metric ton) (Ref. VIII-6). Total cost would therefore be $13.45 to $16.45 per wet ton ($14.81 to $18.12/metric ton); annual cost would be $670,300 to $820,110. Using a mean cost of landfilling ($13.50 per wet ton), and $1.45 per wet ton transportation, the total annual cost is $676,700, of which $184,400 is annual amortized capital costs and $492,300 O&M. Applying the methodology to existing WTP processing equipment would add an annual amortized capital cost of $813,000 and O&M of $250,000.

8.1.4 Disposal Ponds

This plant currently practices on-site ponding of the incinerator ash. It is estimated that cost of ash ponding is $0.14 to $0.50 per wet ton ($0.15 to $0.55/metric ton) (Ref. VIII-4). Transport costs (piping) are estimated to be $0.03 per wet ton ($0.03/metric ton). Total costs of transport and ponding is $0.17 to 0.53 per wet ton ($0.18 to $0.58/metric ton), or a mean annual cost of $39,500 of which $9,200 is annual amortized capital costs and $30,300 O&M. Applying the methodology to existing WTP process equipment, would add an annual amortized capital cost of $1,083,600 and O&M of $331,000.

If ponding is the sole means of ultimate disposal, the ponds will eventually be filled. It will then be necessary either to find more land for new ponds or to practice another method of disposal.

If ponding is not the ultimate means of solids disposal, then the dewatered, settled solids from the pond must be removed periodically for landfill disposal. When ponding is thus combined with landfilling, the ponds can be used almost indefinitely.

8.2 LITTLE MIAMI WASTEWATER TREATMENT PLANT

Influent rate at the Little Miami WTP is 31 mgd (117,800 m^3/d). Evaluations are based on daily generation of the following types and quantities of sludge (see Appendix B):

Sludge type	Quantity tons(metric tons)/d	Percent solids
Raw sludge	417(378)	4.0
Raw sludge (from holding tanks)	250(227)	7.0
Anaerobically digested sludge*	210(191)	5.0
Filter cake	42(38)	25.0
Ash from Incineration:		
Dry basis	16.8(15.3)	100.0
Wet basis	244(203)	7.5

* The digestors are presently used as holding tanks, but could be converted back to function as anaerobic digestors. It is assumed that as a result of the digestion process, a 45 percent reduction in total solids is achieved (Ref. VIII-12); that the solids content of the digested sludge is 5 percent (Ref. VIII-13); that solids content of filter cake is 25 percent (Ref. VIII-4); that the ash content of digested filter cake upon incineration is 40 percent (Ref. VIII-13).

Ponding of raw sludge is not considered acceptable because of possible leachate and odor problems. Currently the Little Miami WTP hauls the sludge to the Mill Creek WTP for dewatering and incineration.

The Little Miami WTP plans to have four vacuum filters, two incinerators, and ash lagoons on line by 1977; this equipment will facilitate sludge processing and disposal on-site. Therefore the following scenarios reflect those possible alternatives when all process equipment is operating.

8.2.1 Land Spreading (Wet)

Anaerobically digested sludge from this plant can be transported to agricultural areas in eastern Clermont County for wet land spreading. Most soils in eastern Clermont County are acceptable for land spreading, however care should be taken to avoid some areas with seasonal high water tables. Soils of the former association, however, are acceptable for land spreading. Since little groundwater is available in this area of Clermont County, no adverse effects are foreseen. Slope in the area is acceptable for such practice. Areas closer to the treatment plant are projected to become urban and suburban and thus unsuitable for wet land spreading.

No rail facilities or navigable waterways serve the area, which is about 60 miles (96 km) round trip distance from the Little Miami WTP. Anaerobically digested sludge transport would be by truck or by pipeline. Although cost data are not cited, it appears that piping of the comparatively small amount of sludge over such a distance would not be economic by virtue of high unit costs for operation and capitalization. Trucking is therefore considered the best way to transport the sludge.

Trucking costs for the 60 miles (96 km) trip are estimated as $2.80 per wet ton ($3.08/metric ton); (Ref. VIII-4); land spreading costs are estimated at $1.08 per wet ton ($1.19/metric ton) (Ref. VIII-4). Total estimated cost of transport and spreading is therefore $3.88 per wet ton ($4.27/metric ton). On an annual basis the cost is $297,402, of which $124,143 is annual amortized capital costs and $173,259 O&M. Applying the methodology to the existing WTP process equipment would add an annual amortized capital cost of $150,500 and O&M of $19,000.

8.2.2 Land Spread (Dry)

The land available for spreading of the anaerobically digested sludge could also be used for spreading of the filter cake. Estimated truck transport costs for the 60 miles (96 km) round trip distance would be $2.90 per wet ton ($3.19/metric ton) of filter cake (Ref. VIII-5). Cost of dry land spreading is estimated to be $1.23 per wet ton ($1.35/metric ton) of filter cake (Ref. VIII-10, 11). Total cost of transport and dry land spreading is $4.13 per wet ton ($4.55/metric ton) or an annual cost of $63,313 of which $23,293 is annual amortized capital cost and $40,020 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $176,596 and O&M of $38,000.

8.2.3 Landfilling

A landfill site can possibly be located on the same area as proposed for ponding of the slurried incineration ash by the Little Miami WTP. Cost of truck transport is estimated to be $1.16 per wet ton ($1.28/metric ton) of filter cake (Ref. VIII-5). Cost of landfilling is estimated at $12 to $15 per wet ton ($13.22 to $16.52/metric ton) (Ref. VIII-6). Total cost of transport and landfilling is therefore estimated to be $13.16 to $16.16 per wet ton ($14.49 to $17.80/metric ton). Using a mean cost of landfilling ($13.50 per wet ton) and $1.16 per wet ton transportation, the total annual cost is $224,738, of which $60,310 is annual amortized capital cost and $164,428 O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $176,596 and O&M of $38,000.

8.2.4 Disposal Ponds

The Little Miami WTP proposes to pond their slurried ash approximately 4 miles (6.4 km) round trip distance from the plant site. No cost estimates were available from the plant, therefore the following estimates are developed. Ponding cost is estimated to be $0.14 to $0.50 per wet ton ($0.15 to $0.55/metric ton) (Ref. VIII-4). Transport costs (tank truck) are estimated to be $0.30 per wet ton ($0.33/metric ton). Total cost of transport and ponding is $0.44 to $0.80 per wet ton ($0.49 to $0.88/metric ton), or a mean annual cost of $50,691 of which $18,363 is annual amortized capital cost and $32,328 O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $264,930 and O&M of $68,000.

8.3 SANITATION DISTRICT NO. 1 OF CAMPBELL AND KENTON COUNTIES, NORTHERN KENTUCKY (BROMLEY WTP)

Influent rate at the Bromley WTP is 20.8 mgd (79,040 m^3/d). Evaluations are based on daily generation of the following types and quantities of sludge and residual (see Appendix B):

Sludge type or Residual	Quantity tons(metric tons)/d	Percent solids
Raw sludge	197(179)	3.8
Filter cake	19.4(17.6)	38.0
Ash from Incineration:		
Dry basis	0.20(0.18)	100.0
Wet basis	2.7(2.5)	7.5
Anaerobically digested sludge*	47.7(43.3)	9.1
Filter cake*	13.2(11.9)	33.0
Ash from Incineration:*		
Dry basis	7.4(6.7)	100.0
Wet basis	98.7(89.6)	7.5

* Values represented by an asterisk (*) reflect the quantity of sludge or ash as a result of processing at the Mill Creek WTP.

The Bromley WTP will be phased out when the Dry Creek WTP comes on-line in 1977. Currently, the Bromley WTP dewaters the sludge by vacuum filtration followed by incineration of the filter cake. The incinerator ash is slurried and disposed of in the Ohio River. Alternatives to the current disposal method include wet and dry land spreading, landfilling, and ponding. However, in order to implement any of these four ultimate disposal practices, a sludge stabilization process such as chemical treatment would have to be implemented. Moreover, a total amortized capital cost of $32,119 could not reasonably be recovered in the remaining two years of plant operation. In addition, $10,000 annual O&M would be incurred. Lastly, the design and construction of a chemical treatment process in all probability would take no less than two years to complete - the remaining life of the plant. Therefore, implementation of such a process is impractical.

As a result of this unique situation, it may be practical to truck transport the raw sludge to the Mill Creek WTP for further treatment and processing.

The ultimate disposal of the sludge would be by one of the four disposal alternatives as discussed for the Mill Creek WTP. The Bromley WTP would have to absorb its proportional costs for any of the four disposal alternatives. The following disposal alternatives therefore reflect the cost that would be incurred by the Bromley WTP for each alternative as reflected in a user charge paid to Mill Creek WTP. Bromley WTP would also incur a cost for transport by tank trucks 16 miles (25 km) round trip to the Mill Creek WTP. This cost is estimated to be $1.90 per wet ton ($2.09/metric ton) (Ref. VIII-4). Cost on an annual basis for this segment of transport is estimated to be $136,620, of which $65,851 is annual amortized capital and $70,769 is O&M.

8.3. Land Spreading (Wet)

Land spreading of the anaerobically digested sludge before it is vacuum filtered or the slurried ash* could be practicable. Cost of transport for the 50 miles (80 km) round trip distance is estimated to be $2.20 per wet ton ($2.42/metric ton) of either anaerobically digested sludge or slurried ash (Ref. VIII-4). Cost of wet land spreading either the digested sludge or the ash is estimated to be $1.08 per wet ton ($1.19/-metric ton) (Ref. VIII-4). Total cost of transport and land spreading therefore is $3.28 per wet ton ($3.61/metric ton). Total annual cost** of transport and disposal of the digested sludge is $193,726 of which $89,014 is annual amortized capital and $104,712 is annual O&M. Applying the methodology, existing process equipment would add an annual amortized capital cost of $200,760 and O&M of $8,000.

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* Represents sludge or ash residual as a result of processing at the Mill Creek WTP.

** Total Annual Cost = (total cost of transport and disposal) x (total wet tons per day) x (365 days per year) + (annual cost of transporting raw sludge from Bromley WTP to Mill Creek WTP).

Analogously, wet land spreading of the ash slurry in quantities of 98.7 wet tons (89.6 metric tons) per day would cost $254,784. Of this total $113,779 is annual amortized capital and $141,005 is annual O&M. Applying the methodology, existing process equipment would add an annual amortized capital cost of $285,071 and O&M of $38,000.

8.3.2 Land Spreading (Dry)

The land available for spreading of digested sludge could also be used for spreading of dewatered sludge. The average cost of round trip transport for the 50 miles (80 km) distance would be $2.75 per wet ton ($3.03/metric ton) (Ref. VIII-5). Spreading costs are estimated at $1.24 per wet ton ($1.36/metric ton) of filter cake (Ref. VIII-10,11). Total cost of transport and dry land spreading would be $3.99 per wet ton ($4.40/metric ton). Total annual cost of transport and disposal is $155,844, of which $72,821 is annual amortized capital costs, and $83,023 O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $234,887 and O&M of $24,000.

8.3.3 Landfilling

The filter cake* could be disposed of in landfills. The nearest landfill that could accept the sludge cake is located about 20 miles (32 km) round trip from the plant on Este Avenue. The only feasible means of transporting the sludge cake to the landfill would be by truck, since there are no rail services or navigable waterways, and piping would not be suitable. Cost of truck transport would be $1.45 for wet ton ($1.60/-metric ton) (Ref. VIII-5). Cost of landfilling is estimated to be $12 to $15 per wet ton ($13.21 to $16.52/metric ton) (Ref. VIII-6). Total cost would therefore be $13.45 to $16.45 per wet ton ($14.81 to $18.12/metric ton). Annual cost would be $201,422 to $215,876. Using a mean cost of landfilling ($13.50 per wet ton), and $1.45 per wet ton transportation, the total annual cost is $208,649, of which $85,479 is annual amortized capital cost and $123,170 O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $234,887 and O&M of $24,000.

8.3.4 Pond Disposal

The slurried ash resulting from incineration could be ponded in the on-site ash pond at the Mill Creek WTP. Cost of ash ponding is estimated at $0.14 to $0.50 per wet ton ($0.15 to $0.55/metric ton) (Ref. VIII-4). Transport costs (piping) are estimated to be $0.03 per wet ton ($0.03/-

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* Represents sludge or ash residual as a result of processing at the Mill Creek WTP.

metric ton). Cost of transport and ponding is $0.17 to $0.53 per wet ton ($0.18 to $0.58/metric ton). The mean annual cost is $12,609 plus $136,620 to transport raw sludge from Bromley WTP to Mill Creek WTP or an annual total of $149,229 of which $69,003 is annual amortized capital and $80,226 O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $285,071 and O&M of $38,000.

8.4 MIDDLETOWN WASTEWATER TREATMENT PLANT

Influent rate at the Middletown WTP is 10 mgd (38,000 m^3/d). Evaluations are based on daily generation of the following types and quantities of sludge and residual (see Appendix B):

Sludge type or Residual	Quantity tons(metric tons)/d	Percent solids
Raw sludge	103(94)	6.9
Waste activated sludge	413(375)	1.0
Combined wet sludge	516(469)	2.2
Filter cake	60(54)	26.0
Ash from Incinerator:		
Dry basis	6.5(5.9)	100
Wet basis	87(79)	7.5

Middletown WTP employs anaerobic digestion, vacuum filtration, incineration, and ash lagooning. The ash residue from the lagoon is periodically hauled from the plant by private contractors. As long as the ash is hauled from the lagoons, this method of disposal should remain adequate. Other possible alternatives for disposal of sludge or residuals include wet or dry land spreading and landfilling.

8.4.1 Land Spreading (Wet)

Land spreading of the combined wet sludge after it has been stabilized may be possible in rural areas west of Middletown. Soils in this area appear acceptable for land spreading. Some sites in the area, however, may have a high water table for short periods of time. Slope is acceptable for land spreading. A round trip of 30 miles (48 km) would be required.

Transport of the combined wet sludge would cost approximately $2.00 per wet ton ($2.20/metric ton) (Ref. VIII-4). Cost of land spreading is estimated at $1.08 per wet ton ($1.19/metric ton) (Ref. VIII-4). Total cost of transport and spreading is therefore $3.08 per wet ton ($3.39/-metric ton), or $580,090 annually, of which $232,100 is annual amortized capital cost and $347,990 O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $80,000 and O&M of $20,000.

8.4.2 Land Spreading (Dry)

Dry land spreading of the filter cake might be done in the same agricultural area as described for wet land spreading.

Because piping would not be economical and there are no rail facilities or navigable waterways to the site of disposal, trucking would be the best method of transport. Estimated truck transport cost is $1.16 per wet ton ($1.28/metric ton) (Ref. VIII-5). Costs of dry land spreading is estimated to be $1.25 per wet ton ($1.38/metric ton) of filter cake (Ref. VIII-10). Total costs of transport and dry land spreading is $2.41 per wet ton ($2.66/metric ton) or an annual cost of $52,800 of which $14,900 is annual amortized capital costs and $37,900 O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $129,200 and O&M of $55,000.

8.4.3 Landfilling

Landfilling of the filter cake could be done in the same area but would require construction of a landfill facility. Truck transport costs would be $1.16 per wet ton ($1.28/metric ton) of filter cake (Ref. VIII-5). Cost of construction and operation of the landfill is estimated at $12.00 to $15.00 per wet ton ($13.21 to $16.52/metric ton) (Ref. VIII-6). Total cost for transport and landfilling therefore would be $13.16 to $16.16 per wet ton ($14.49 to $17.80 per metric ton). Annual cost would be $262,800 to $328,500. Using a mean cost of landfilling ($13.50 per wet ton), and $1.16 per wet ton transportation, the annual cost is $321,050, of which $86,100 is annual amortized capital costs and $234,950 O&M. Applying the methodology to the existing WTP, process equipment would add an annual amortized cost of $129,200 and O&M of $55,000.

8.4.4 Pond Disposal

Ponding is used in an area adjacent to the treatment plant for disposal of incinerator ash. This does not constitute an ultimate means of disposal since the ash must be removed periodically. Local contractors now haul the ash residue for use as bedding in pipeline construction. It is estimated that the cost of ponding of ash is $0.14 to $0.50 per wet ton ($0.15 to $0.55/metric ton) (Ref. VIII-4). Transport cost (piping) are estimated to be $0.11 per wet ton ($0.12/metric ton). Total cost of transport and ponding is $0.25 to $0.61 per wet ton ($0.27 to $0.57/metric ton) or a mean annual cost of $13,700 of which $2,700 is annual amortized capital cost and $11,000 O&M. Applying the methodology to existing WTP process equipment, would add an annual amortized capital cost of $197,000 and $71,000 O&M.

8.5 FRANKLIN WASTEWATER TREATMENT PLANT

Influent rate at the Franklin WTP is 9.0 mgd (34,200 m^3/d). Evaluations are based on daily generation of the following types and quantities of sludge (see Appendix B):

Sludge type	Quantity tons(metric tons)/d	Percent solids
Raw sludge (Municipal)	16.6(15.1)	6.0
Raw sludge (Industrial)	229(208)	7.0

Landfilling and dry land spreading are not considered feasible, since the Franklin plant lacks dewatering capabilities.

Franklin WTP now land spreads raw industrial sludge and pipes raw municipal sludge to the solid waste plant for incineration. Ash from the incinerator presently is recycled to the primary industrial clarifier. If the land spreading of raw sludge, causes no adverse environmental impacts, this method could be continued for the life of the land spreading site.

8.5.1 Land Spreading (Wet)

The industrial sludge is transported by pipeline about 1000 feet (305 m) long for spreading on agricultural and open land adjacent to the plant. There is some potential of adverse impact on surface and groundwaters, since the spreading site is located on the flood plain of the Great Miami River. Thus far, however, samples obtained from 14 groundwater monitoring wells operated by the Miami Conservancy District have indicated no adverse impact to groundwater. PEDCo's analysis of a composite sludge sample indicates that the sludge contains high levels of cadmium and zinc. These constituents pose a potential threat not only to ground and surface waters but possibly to crops grown on the sludge. Plant records show that pipe transport costs $0.04 per wet ton ($0.04/metric ton) of municipal industrial sludge. Cost of spreading is estimated to be $1.08 per wet ton ($1.19/metric ton) (Ref. VIII-4). Total estimated cost of transport and spreading is $1.12 per wet ton ($1.23/metric ton).

On an annual basis the cost is $93,800 of which $22,700 is annual amortized capital and $71,100 O&M.

8.5.2 Disposal Ponds

Disposal by ponding at the site adjacent to the Franklin WTP would offe no advantage over wet land spreading because disposal would still be on the flood plain of the Great Miami River. Other sites some 15 miles (24 km) away in areas to the east or west would be environmentally more suitable. Sludge transport by truck would be the most economical means. Soils appear acceptable for land spreading as well as do slope conditions in the area. Potential for groundwater contamination also is minimal if flood plain areas are avoided.

As an approximation, cost of transport over a 30-mile (48 km) round trip distance to the disposal site would be about $1.40 per wet ton ($1.54/metric ton) (Ref. VIII-4). Disposal costs may range from $0.14 to $0.50 per wet ton ($0.15 to $0.55/metric ton) (Ref. VIII-4). Therefore, total cost of transport and ponding would be $1.54 to $1.90 per wet ton (0.92 to $1.32/metric ton). Using a mean cost of $0.32 for ponding and $1.40 transportation a mean annual cost of $143,800 of which $63,100 is annual amortized capital cost and $80,700 O&M would be incurred.

8.6 MUDDY CREEK WASTEWATER TREATMENT PLANT

Influent rate at the Muddy Creek WTP is 8.3 mgd (31,500 m^3/d). Evaluations are based on daily generation of the following types and quantities of sludge and residual (see Appendix B):

Sludge type or residual	Quantity tons(metric tons)/d	Percent solids
Raw sludge	117(106)	6
Waste activated	30(27)	1
Thermally conditioned sludge	147(133)	5
Filter cake	19.6(17.8)	35 to 40
Ash from incineration	79 (71.7)	7.5

Landfilling of the incinerator ash is not considered feasible since the ash is in a slurried state. The plant now practices vacuum filtration, incineration, and subsequently lagooning of the slurried ash. If no harmful environmental impact results, this method of disposal will remain acceptable for the future.

8.6.1 Land Spreading (Wet)

Land spreading of the thermally conditioned sludge from the Muddy Creek plant might be done in rural areas to the north and west of the plant. The most suitable sites for land spreading are in Dearborn County, Indiana, which contains large areas of agricultural and undeveloped land. Kelso, Logan, and Harrison Townships within Dearborn County are easily accessible via I-74, and most of the area is zoned agricultural. Hamilton County offers little if any land suitable for land spreading operations. Although the extreme western portion of Hamilton County is rural, it consists mostly of flood plain that is unacceptable for land spreading. Northwest portions of Boone County, although rural, are not easily accessible and the topography is too rugged for land spreading. Urban and suburban areas to the east and northeast of the plant are not acceptable for land spreading.

Soils in Dearborn County appear well suited for land spreading. They are mostly underlain by a hardpan which prevents infiltration into groundwater as well as percolation and movement of soil waters. Groundwater production is very poor. Though topography may be rugged and sloping, many areas are suitable for land spreading.

The thermally conditioned sludge could be transported to the land spreading site by truck or pipeline. Rail service does not extend to the proposed disposal area, nor are there navigable waterways for barge transport. Truck (tank) transport would entail an average round trip of 80 miles (128 km). Since the plant generates 147 wet tons (133 metric tons) per day of thermally conditioned sludge at 5 percent solids, transport cost would be $3.60 per wet ton ($3.96/metric ton) (Ref. VIII-4). Cost of spreading is estimated at $1.08 per wet ton ($1.19/metric ton) (Ref. VIII-4). Total cost of transport and land spreading, therefore, is estimated at $4.68 per wet ton ($5.15/metric ton) or $251,105 annually, of which $107,500 is annual amortized capital cost and $143,500 O&M. Applying the methodology to the existing WTP process equipment would add an annual amortized capital cost of $100,380 and $100,000 O&M. Pipeline transport would not be economical because of the long distance and subsequent high head losses.

8.6.2 Land Spreading (Dry)

Land spreading of the filter cake, with solids content of 35 to 40 percent, may also be possible in the same Dearborn County area. The cost of transport is estimated at about $4.64 per wet ton ($5.11/metric ton) of filter cake (Ref. VIII-5). Spreading costs are estimated at $1.33 per wet ton ($1.46/metric ton) of filter cake (Ref. VIII-10,11). Total cost of transport and dry land spreading is estimated to be $5.97 per wet ton ($6.57/metric ton). Total annual cost of transport and disposal is $42,700 of which $17,400 is amortized capital cost and

$25,300 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $120,000 and $116,000 O&M.

8.6.3 Landfilling

Hamilton County has only one landfill reasonably near the Muddy Creek WTP. It is located in an industrial park approximately 20 miles (32 km) from the plant. Since this landfill accepts residential and common commercial waste, it may be possible to mix the filter cake with solid waste in the landfilling process. Hamilton County is considering a resource recovery plant to process solid waste. Such an operation would reduce the flow of solid waste into the landfill by 75 percent and extend the life of the landfill by as much as 30 years. The landfill might then provide long-term disposal for the filter cake.

Transport of the filter cake by truck to the disposal site would be about $3.90 per wet ton ($4.30/metric ton) (Ref. VIII-5). Cost of landfilling would be about $12 to $15 per wet ton ($13.22 to $16.52/-metric ton) (Ref. VIII-6). Total cost of transport and landfilling would therefore be $15.90 to $18.90 per wet ton ($17.52 to $20.82/metric ton) of filter cake. On an annual basis, the cost would be $113,750 to $135,210. Using a mean cost of landfilling ($13.50 per wet ton) and $3.90 per wet ton transportation, the annual cost is $124,480 of which $37,500 is annual amortized capital cost and $86,980 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $120,000 and $116,000 O&M.

Again, neither rail service nor barge transport is available.

8.6.4 Disposal Ponds

The plant presently performs incineration with subsequent ponding of the slurried ash on site. Though no cost figures were available from the plant, it is estimated that the cost of ponding is $0.14 to $0.50 per wet ton ($0.15 to $0.55/metric ton) of slurried ash (Ref. VIII-4). Transport costs (piping) are estimated to be $0.12 per wet ton ($0.13/-metric ton). Total cost of transport and spreading is estimated to be $0.26 to $0.62 per wet ton ($0.27 to $0.67/metric ton) or a mean annual cost of $12,687 of which $2,500 is annual amortized capital and $10,187 is O&M. Applying the methodology to existing WTP process equipment would add an annual capital amortized cost of $108,400 and $49,000 O&M.

8.7 HAMILTON WASTEWATER TREATMENT PLANT

Influent rate at the Hamilton WTP is 7 mgd (26,600 m^3/d). Evaluations are based on daily generation of the following types and quantities of sludge (see Appendix B):

Sludge type	Quantity tons(metric tons)/d	Percent solids
Raw sludge	254(231)	3.5
Filter cake	50(45)	20.0
Anaerobically digested sludge*	97.8(88.8)	5
Filter cake*	19.6(17.8)	25

* Represents the quantity of sludge that will result if the thickeners are converted back to their original function as anaerobic digestors (Ref. VIII-12,13). Only anaerobically digested sludge could be considered for land spreading, landfilling or ponding.

The plant presently employs vacuum filtration and landfills the filter cake. The landfill has an expected life of 5 years, after which a new landfill site must be located or a new method of disposal implemented.

8.7.1 Land Spreading (Wet)

The anaerobically digested sludge could be spread in a rural area approximately 10 round trip miles (16 km) to the north and west of the plant. Soils in this area appear acceptable for land spreading. Since groundwater availability is moderate, care must be taken to prevent groundwater contamination. Slope is acceptable for land spreading operations. Transport costs are estimated at $3.00 per wet ton ($3.30/-metric ton) (Ref. VIII-4). Land spreading costs are estimated to be $1.08 per wet ton ($1.19/metric ton) of anaerobically digested sludge (Ref. VIII-4). Total cost of transport and spreading of wet sludge is estimated to be $4.08 per wet ton ($4.49/metric ton) or $145,644 annually, of which $61,256 is annual amortized capital cost and $84,388 O&M. Applying the methodology to the existing WTP process equipment would add an annual amortized capital cost of $80,000 and $11,000 O&M.

8.7.2 Land Spreading (Dry)

Land spreading of the filter cake (provided its derivation is from an anaerobically digested sludge) could be done in the same rural area. Soils and hydrologic characteristics in this area appear suitable. Areas east and south, which are projected to become urbanized, afford no sites for land spreading.

Transport could best be done by truck. Rail and barge transport are not available and piping costs would be prohibitive for such a low throughput.

Cost of trucking round trip for 10 miles (16 km) is estimated to be $0.87 per wet ton ($0.96/metric ton) of filter cake (Ref. VIII-5). Cost of spreading filter cake is estimated at $1.28 per wet ton ($1.41/metric ton) of filter cake (Ref. VIII-10). Total cost of transport and dry land spreading is $2.15 per wet ton ($2.36/metric ton) of filter cake. Total annual cost of transport and spreading is $15,381 of which $4,061 is amortized capital cost and $11,320 O&M. Applying the methodology to the existing WTP process equipment would add an annual amortized capital cost of $96,400 and $25,000 O&M.

8.7.3 Landfilling

Filter cake from the plant is now disposed of in a landfill 1.0 round trip miles (1.6 km) from the plant. Area of this city-owned landfill is sufficient to permit continued disposal for at least 5 years at the plant design rating. No firm-fixed cost data were available from the plant. Cost of transport of the filter cake is therefore estimated at $0.58 per wet ton ($0.64/metric ton) (Ref. VIII-5). Cost of landfilling is estimated between $12 to $15 per wet ton ($13.22 to $16.52/metric ton) (Ref. VIII-6). Total annual cost is estimated at $229,585 to $284,335. Using a mean cost of landfilling ($13.50 per wet ton) and $0.58 per wet ton transportation, the annual cost is $256,960 of which $65,700 is annual amortized capital cost and $189,260 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $37,100 and $27,000 O&M. Since the filter cake is not stabilized, this is not considered an environmentally acceptable disposal practice (Ref. VIII-13).

In order for landfilling to be environmentally safe practice, it is recommended that the thickeners be converted back to their original function as anaerobic digestors. Using a mean cost of landfilling ($13.50 per wet ton) and $0.58 per wet ton transportation, the annual cost is $100,728 of which $26,145 is annual amortized capital cost and $74,583 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $96,400 and $25,000 O&M.

8.7.4 Disposal Ponds

Anaerobically digested sludge might be ponded in the nearby areas already described. Transport costs are estimated to $1.50 per wet ton ($1.65/-metric ton) (Ref. VIII-4). Cost of ponding is estimated to be $0.14 to $0.50 per wet ton ($0.15 to $0.55/metric ton) (Ref. VIII-4). Total cost of transport and ponding would be $1.64 to $2.00 per wet ton ($1.80 to $2.20/metric ton) or a mean annual cost of $64,968 of which $28,665 is annual amortized capital cost and $36,304 O&M. Applying the methodology to the existing WTP process equipment, would add an annual amortized capital cost of $80,304 and $11,000 O&M.

8.8 SYCAMORE CREEK WASTEWATER TREATMENT PLANT

Influent rate at the Sycamore WTP is 3.5 mgd (13,300 m^3/d). Evaluations are based on daily generation of the following types and quantities of sludge (see Appendix B):

Sludge type	Quantity tons(metric tons)/d	Percent solids
Raw sludge	58(53)	4.0
Waste activated sludge	67(61)	0.5
Combined wet sludge	125(114)	2.0
Anaerobically digested sludge	25(23)	7.0

Dry land spreading and landfilling are not considered for the Sycamore WTP since the plant has no dewatering capabilities. Ponding is not considered because land near the plant is not suitable for such a purpose. Sludge from the plant is now hauled to the Mill Creek WTP for dewatering and incineration.

8.8.1 Land Spreading (Wet)

Land application of the anaerobically digested sludge from the Sycamore plant is feasible for two reasons: 1) the plant receives an insignificant industrial waste load, and 2) the plant is located in a rural farming area.

The anaerobically digested sludge would be transported by truck. Rail transport is not feasible because of short haul distances. Pipeline transport would be impractical since it limits distribution of the sludge to one or two points, whereas more than one land spreading area would be required.

Nearest area suitable for spreading is in Clermont County, about 40 round trip miles (64 km) from the plant. Soils in this area appear acceptable for land spreading. Some soils however often develop a high water table in winter and spring and they should be avoided in selection of a specific site within the area. Slope in the area appears acceptable for land spreading.

The anaerobically digested sludge could be wet land spread provided its inherent odor causes no nuisance problem. Hauling costs are estimated to be $1.80 per wet ton ($1.98/metric ton), and land spreading costs are estimated to be $1.08 per wet ton ($1.19/metric ton). Total cost of transport and hauling is $2.88 per wet ton ($3.17/metric ton). Annual cost would be $26,280 of which $10,400 is annual amortized capital and $15,880 is O&M. Applying the methodology to the existing WTP process equipment would add an annual amortized capital cost of $20,000 and $20,000 O&M.

8.9 OXFORD WASTEWATER TREATMENT PLANT

Influent rate at the Oxford WTP is 2.64 mgd (10,000 m^3/d). The evaluations are based upon daily generation of the following types and quantities of sludge (see Appendix B):

Sludge type	Quantity tons(metric tons)/d	Percent solids
Raw plus return secondary sludge	37(34)	6.0
Anaerobically digested sludge	2.05(1.9)	5.0

Dry land spreading and landfilling are not practicable because the Oxford WTP has no dewatering capabilities. The plant now spreads the anaerobically digested sludge on agricultural land. If no adverse environmental impacts occur or are monitored, this method of disposal should prove satisfactory for the future.

8.9.1 Land Spreading (Wet)

Although the area immediately surrounding Oxford is projected to become urbanized over the next 20 years, land spreading remains a suitable means of sludge disposal because the city is situated in a predominately rural region. Even after projected urbanization, land spreading sites will be available about 7 miles (11 km) distant in all directions from the plant. For the purposes of evaluation, a mean round trip transport distance of 14 miles (22 km) is assumed.

Soils in the areas of possible land spreading near the plant have moderately low permeability. Since this area is a poor source of groundwater, contamination of groundwaters in the spreading areas would be unlikely. Topography is flat to gently sloping. Thus, the soils and the hydrologic and topographic features are well suited for land spreading.

Since there are no navigable waterways or rail facilities in the area, transport is limited to truck or pipe. Available data indicate that piping would be uneconomical in this instance by virtue of short distances and low throughput. Trucking, therefore, is the optimum means of transport.

Costs of hauling the anaerobically digested sludge are estimated to be $0.88 per wet ton ($0.96/metric ton) (Ref. VIII-4). Land spreading costs are estimated to be $1.08 per wet ton ($1.19/metric ton) (Ref. VIII-4). Total cost for transport and spreading of the anaerobically digested sludge would be $1.96 per wet ton ($2.16/metric ton), or $1,467 annually of which $500 is annual amortized capital costs and $967 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $10,000 and $10,000 O&M.

8.9.2 Disposal Ponds

In view of the projected urbanization of the area near the plant, a pond or lagoon for disposal of the anaerobically digested sludge should be located at a site remote from the treatment plant. Since potential sites would therefore be approximately the same distance from the plant as the land spreading sites, ponding would incur the same transport costs as those for wet land spreading. Estimates of ponding costs are $0.14 to $0.50 per wet ton ($0.15 to $0.55/metric ton) (Ref. VIII-4). Total cost for transport and ponding is estimated to be $1.02 to $1.38 per wet ton ($1.12 to $1.51/metric ton), or a mean annual cost of $898 of which $400 is annual amortized capital cost and $598 O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $10,000 and $10,000 O&M.

8.10 LAWRENCEBURG WASTEWATER TREATMENT PLANT

Influent rates at the Lawrenceburg WTP are 1.4 mgd (5,320 m^3/d) at plant No. 1 and 2.5 mgd (9500 m^3/d) at plant No. 2. Evaluations are based on daily generation of the following types and quantities of sludge (see Appendix B):

Sludge type	Quantity tons(metric tons)/d	Percent solids
Waste secondary sludge (Plant No. 2)	950(863)	2.0
Industrial Sludge (Plant No. 1)	333(303)	0.3
Combined waste secondary plus industrial sludge	1,283(1,165)	1.5
Anaerobically digested sludge	212(194)	5.0
Filter cake*	2.1(1.9)	25.0

* Very little of the anaerobically digested sludge is vacuum filtered: most of it is recycled.

The Lawrenceburg WTP presently vacuum filters 2.1 wet tons (1.9 metric tons) of combined waste secondary plus industrial sludge per day which is then subsequently land spread. The sludge which is not vacuum filtered is sent back to plant No. 2, where it is allowed to settle in the clarifier and periodically wasted.

8.10.1 Land Spreading (Wet)

Wet land spreading of the anaerobically digested sludge could be accomplished prior to vacuum filtration. This would result in distributing a wet sludge of 5 percent solids. Permeability characteristics of the soils nearby are not well suited for wet land spreading, however, and rugged topography is another deterrent. Northern portions of the county about 10 round trip miles (16 km) distance would be suitable for wet land spreading. Soils in this area appear acceptable for land spreading with little danger to groundwaters. Though slope is extreme in places, several acceptable areas are available in this locale. Transport costs are estimated at about \$2.32 per wet ton (\$2.54/metric ton) of anaerobically digested sludge (Ref. VIII-4). Land spreading costs are estimated at about \$1.08 per wet ton (\$1.19/metric ton) of anaerobically digested sludge (Ref. VIII-4). Total cost of transport and spreading therefore is \$3.40 per wet ton (\$3.74/metric ton) or \$263,092 annually. Of this total \$107,423 is annual amortized capital and \$155,669 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of \$170,600 and \$24,000 O&M.

8.10.2 Land Spreading (Dry)

Since the city is located near rural areas, dry land spreading is feasible and is currently practiced at the plant. Farmers haul the filter cake away at their own cost. If the farmers were not to handle the filter cake land spreading could be done at a distance of 10 round trip miles (16 km) from the plant in all directions except to the east where the available land consists of river flood plains. Transport is best accomplished by truck since there are no rail or barge facilities and piping of the relatively small amount of sludge would not be economical.

The costs involved are those for transport and spreading of the filter cake. Assuming a round trip distance of 10 miles (16 km) the hauling cost is estimated to be \$1.16 per wet ton (\$1.28/metric ton) of filter cake (Ref. VIII-5). Spreading costs are estimated at \$1.57 per wet ton (\$1.73/metric ton) of filter cake (Ref. VIII-10,11). Total cost of transport and dry land spreading is \$2.73 per wet ton (\$3.01/metric ton). Total annual cost of transport and disposal is \$2,092 of which \$1,100 is amortized capital cost and \$992 O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of \$20,000 and \$20,000 O&M.

8.10.3 Landfilling

The City of Lawrenceburg operates its own landfill for solid waste. Use of this landfill for filter cake disposal is not acceptable since the landfill is situated on a flood plain and is susceptible to seasonal flooding. Locating of a new landfill near the treatment plant is unacceptable for the same reasons cited in the analysis of wet land spreading. An environmentally acceptable area would be, as for wet land spreading, about 10 round trip miles (16 km) away.

Transport costs would be about $1.16 per wet ton ($1.28/metric ton) (Ref. VIII-5). Landfilling costs are estimated at $12.00 to $15.00 per wet ton ($13.21 to $16.52/metric ton)(Ref. VIII-6). Total cost for transport and landfilling is estimated at $13.16 to $16.16 per wet ton (14.49 to $17.80/metric ton) of filter cake. Annual cost would be $10,100 to $12,400. Using a mean cost of landfilling ($13.50 per wet ton), and $1.16 per wet ton for transportation, the total annual cost is $11,237 of which $3,000 is annual amortized capital and $8,237 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $20,000 and $20,000 O&M. This method of disposal appears highly economical, but not all the combined waste secondary plus industrial sludge is vacuum filtered at the Lawrenceburg WTP. Only a very small portion is filtered; the remainder is recycled.

8.10.4 Disposal Pond

Since soils in the vicinity of the plant are not suitable for landfilling they are by no means suitable for ponding of the anaerobically digested sludge. A disposal pond would have to be located in the areas mentioned earlier, about 10 round trip miles (16 km) from the plant. Cost of transport is estimated to be the same as for wet land spreading. Cost of ponding is estimated to be from $0.14 to $0.50 per wet ton ($0.15 to $0.55/metric ton) of anaerobically digested sludge (Ref. VIII-4). Total cost of transport and ponding is therefore estimated to be $2.46 to $2.82 per wet ton ($2.71 to $3.11/metric ton), or a mean annual cost of $204,284 of which $92,721 is annual amortized capital cost and $111,563 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $170,600 and $24,000 O&M.

8.11 BETHEL WASTEWATER TREATMENT PLANT

Influent rate at the Bethel WTP is 0.47 mgd (1786 m^3/d). Evaluations are based on daily generation of the following type and quantities of sludge (see Appendix B):

Sludge type	Quantity tons(metric tons)/d	Percent solids
Raw sludge	Not known	Not known
Anaerobically digested sludge	5.7(5.2)	4.0 (estimated)

Dry land spreading and landfilling are not evaluated since the Bethel WTP has no dewatering capabilities. Ponding cannot be considered because ordinances against landfills in most parts of Clermont County would also prohibit operation of sludge lagoons. The Bethel WTP now hauls the sludge to unknown destinations and disposes of it by various methods.

8.11.1 Land Spreading (Wet)

Land spreading is a very probable alternative for ultimate disposal of the anaerobically digested sludge from the Bethel WTP. Bethel is located in a rural area which offers many suitable sites.

Soils are underlain with a hardpan that will prevent excessive movement and leaching of sludge. As a result, groundwaters will also be protected from infiltration. Slope is also acceptable for such an operation.

Transport of the sludge would be by truck or pipeline since no rail or barge service is available. Use of pipelines would limit the plant to one or a few of the many available sites for land spreading. Truck hauling, which provides maximum mobility, is considered the most suitable transport method.

Based on a round trip hauling distance of 16 miles (26 km) it is estimated that the anaerobically digested sludge could be transported by tank truck for approximately $1.40 per wet ton ($1.54/metric ton)(Ref. VIII-4). Cost of spreading is estimated to be $1.08 per wet ton ($1.19/-metric ton) (Ref. VIII-4). Total cost of transport and spreading is therefore $2.48 per wet ton ($2.73/metric ton). Annual cost is $5,160. Of this total cost $2,000 is annual amortized capital cost and $3,160 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $10,000 and $10,000 O&M.

8.12 NEW RICHMOND WASTEWATER TREATMENT PLANT

Influent rate at the New Richmond WTP is 0.1 mgd (380 m^3/d). Evaluations are based on daily generation of the following types and quantities of sludge (see Appendix B):

Sludge type	Quantity tons(metric tons)/d	Percent solids
Waste secondary sludge (aerobically digested)	0.82(0.75)	1
Sludge cake (from sand drying beds)	0.041(0.37)	20 (assume)

Landfilling and ponding are not feasible in the New Richmond area because soil permeability, slope, and erosion potential would limit such operations. Land spreading of dewatered sludge would be economically prohibitive because of such minute volumes.

The nearest operating landfill is located in Jackson Township about 25 miles (40 km) from the New Richmond WTP; with the relatively low amounts of sludge generated at this plant, hauling over such a distance would be uneconomical. Ordinances within Clermont County prohibit new landfill sites in most areas; the exclusion may also pertain to disposal ponds.

The plant currently uses sand drying beds with subsequent dry land spreading of the sludge cake during the summer months. In winter the wet sludge is stored in holding tanks that have capacity for several months storage. This practice could most likely be continued in the future, provided no adverse environmental impacts occur.

8.12.1 Land Spreading (Wet)

Land spreading of the aerobically digested waste secondary sludge, though possibly feasible, is not considered the most suitable means of sludge disposal. Soils, hydrology, and topography are not suited for spreading of undewatered sludge. If the aerobically digested waste secondary sludge is to be land spread, sites must be selected with care to prevent adverse environmental impact. Cost of hauling for an average 10-mile (16 km) round trip distance is estimated at $1.20 per wet ton ($1.32/metric ton) (Ref. VIII-4). Cost of spreading is estimated at $1.08 per wet ton ($1.19/metric ton) (Ref. VIII-4). Total cost of transport and spreading therefore is $2.28 per wet ton ($2.51/metric ton) of waste secondary sludge. Cost on an annual basis is $682. Of this total $300 is annual amortized capital cost and $382 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $10,000 and $10,000 O&M.

8.13 FELICITY WASTEWATER TREATMENT PLANT

Influent rate at the Felicity WTP is 0.081 mgd (307 m^3/d). Evaluations are based on daily generation of the following types and quantities of sludge (see Appendix B):

Sludge Type	Quantity tons(metric tons)/d	Percent Solids
Waste activated sludge	1.0(0.91)	1.0

Landfilling is not considered for the Felicity WTP since laws in Clermont County prohibit new landfill sites in most areas; the laws also imply prohibition of disposal ponds. Dry land spreading is not an option because the plant has no dewatering facilities.

The plant now spreads wet activated sludge on farmlands. Disposal of unstabilized sludge in this manner is not considered an environmentally acceptable disposal method (Ref. VIII-13). To correct the problem a sludge stabilization process such as chemical treatment would have to be added to the plant.

8.13.1 Land Spreading (Wet)

Since the Felicity plant is located in a rural area, agricultural land for spreading of chemically treated waste activated sludge is plentiful. Soils in this area are for the most part acceptable for lands spreading. Some soils however may exhibit a seasonal high water table and should be avoided. Groundwater availability in the area is minimal, and potential contamination is slight. Slope is great in only a few places and is suitable in most areas. Cost of hauling for an average 10-mile (16 km) round trip distance is estimated at $1.20 per wet ton ($1.32/metric ton) of chemically treated waste activated sludge (Ref. VII-4). Spreading costs are estimated at $1.08 per wet ton ($1.19/metric ton) of chemically treated waste activated sludge (Ref. VIII-4). Total cost of transport and spreading is therefore $2.28 per wet ton ($2.51/metric ton) of chemically treated waste activated sludge. Cost on an annual basis is $832. Of this total $300 is annual amortized capital cost and $532 is O&M. Chemical treatment process equipment capital cost of $10,000 and $10,000 O&M (Ref. VIII-4).

8.14 MAYFLOWER WASTEWATER TREATMENT PLANT

Influent rate at the Mayflower WTP is 0.035 mgd (133 m^3/d). Evaluations are based on daily generation of the following types and quantities of sludge (see Appendix B):

Sludge type	Quantity tons(metric tons)/d	Percent solids
Waste activated sludge (aerobically digested)	0.36(0.32)	1.0

Dry land spreading and landfilling are not evaluated because the Mayflower WTP has no dewatering facilities. Ponding is also eliminated because few if any areas near the plant or within Hamilton County would be suitable sites for such a disposal pond.

The Mayflower WTP now trucks its waste activated sludge every 2 weeks to the Mill Creek WTP, where it is dewatered and incinerated. This practice appears acceptable for the future.

8.14.1 Land Spreading (Wet)

Agricultural areas suitable for wet land spreading lie 50 round trip miles (80 km) west of the plant in Dearborn County, Indiana. Soils and slopes are suitable for land spreading, and potential for groundwater contamination is low.

Transport probably would be by truck, since no adequate rail or barge service is available and pipeline transport over long distances with minimal throughput would be uneconomical.

Trucking costs are estimated to be $3.00 per wet ton ($3.30/metric ton) of waste activated sludge (Ref. VIII-4). Wet land spreading is estimated to cost $1.08 per wet ton ($1.19/metric ton) of waste activated sludge (Ref. VIII-4). Therefore total cost of transport and spreading would be $4.08 per wet ton ($4.49/metric ton) or $536 annually. Of this total $300 is annual amortized capital cost and $236 is O&M.

8.15 DRY CREEK WASTEWATER TREATMENT PLANT (PROPOSED)

Design influent rate for the Dry Creek WTP is 30 mgd (114,000 m^3/d). The plant is scheduled to be on line in 1977. Evaluations are based on daily generation of the following types and quantities of sludge or residuals in the design year (see Appendix B):

Sludge type	Quantity tons(metric tons)/d	Percent solids
Raw sludge	410(372)	5
Waste activated sludge	3049(2768)	1
Thermally conditioned sludge (combined wet sludge)	457(415)	8
Filter cake	104(94.6)	35
Ash from incinerators:		
Dry basis	14(12.7)	100
Wet basis	187(169)	7.5

Neither ponding or wet land spreading of the ash is considered, since the ash will be disposed of only in dry form.

The plant proposes to thermally condition the combined wet sludge, subject it to vacuum filtration, and incinerate the filter cake, with subsequent disposal of the dry ash in a landfill. If no adverse environmental impacts are observed, this method of ultimate disposal should prove satisfactory.

8.15.1 Land Spreading (Wet)

Land spreading of the thermally conditioned sludge could be done in rural areas about 30 round trip miles (48 km) south of the Dry Creek WTP. Soils in this area have slow permeability and are not subject to seasonally high water tables or flooding and seem well suited for land spreading. Potential for groundwater pollution appears low since groundwater availability is minimal. Slope, though steep in places, allows many acceptable sites for spreading.

Transportation of the sludge would be by truck. Neither rail nor barge service is available, and topography would prohibit economical pipeline transport.

Cost of truck transport would be $1.20 per wet ton ($1.32/metric ton) for the thermally conditioned sludge (Ref. VIII-4). Cost of wet land spreading would be $1.08 per wet ton ($1.19/metric ton) (Ref. VIII-4).

Total cost of transport and spreading would be $2.28 per wet ton ($2.51/metric ton); annual cost would be $380,315. Of this total $141,500 is annual amortized capital cost and $238,815 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $381,380 and $306,000 O&M.

8.15.2 Land Spreading (Dry)

Dry land spreading of the filter cake can be done in the same rural area. Again, transport would be by truck. Cost of truck transport for 30 miles (48 km) round trip distance would be $1.28 per wet ton ($1.41/-metric ton)(Ref. VIII-5). Spreading costs are estimated at $1.23 per wet ton ($1.35/metric ton) of filter cake (Ref. VIII-10,11). Total cost of transport and dry land spreading is $2.51 per wet ton ($2.76/metric ton). Total annual cost is $95,280 of which $27,500 is amortized capital cost and $67,780 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $451,080 and $341,000 O&M.

8.15.3 Landfilling

Although four landfills are operating in Northern Kentucky none are acceptable for handling of sludge because all four sites are subject to flooding. The nearest landfill that could take the sludge is about 24 round trip miles (38 km) from the plant on Este Avenue in Cincinnati.

The cost of truck transport of the wet filter cake would be $1.28 per wet ton ($1.41/metric ton)(Ref. VIII-5). Cost of landfilling would be $12.00 to $15.00 per wet ton ($13.21 to $16.52/metric ton)(Ref. VIII-6). Total cost of transport and landfilling would be $13.28 to $16.28 per wet ton ($14.62 to $17.93/metric ton). Annual cost would be $504,110 to 618,000. Using a mean cost of landfilling ($13.50 per wet ton) and $1.28 per wet ton for transportation, the total annual cost would be $561,048 of which $151,500 is annual amortized capital cost and $409,548 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $451,080 and $341,000 O&M.

The Dry Creek WTP plans to landfill dry ash, and since it is not known where the landfill is going to be located, it is assumed for the purpose of cost evaluation, that the ash will be landfilled in the same area as the filter cake. Therefore the total cost of transport and landfilling would be the same at $13.28 to $16.28 per ton ($14.62 to $17.93/metric ton) of ash. Annual cost would be $67,861 to $83,191. Using the mean cost for landfilling of ($13.50 per wet ton) and $1.28 per wet ton for transportation, the total annual cost would be $75,526, of which $20,400 is annual amortized capital cost and $55,126 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $712,580 and $416,000 O&M.

8.16 LESOURDSVILLE WASTEWATER TREATMENT PLANT (PROPOSED)

Design influent rate for the LeSourdsville WTP is 4.0 mgd (15,200 m^3/d). Evaluations are based on projected daily generation of the following types and quantities of sludge (see Appendix B):

Sludge type	Quantity tons(metric tons)/d	Percent solids
Raw sludge	25(23)	4.0
Secondary sludge	87(79)	2.5
Combined raw plus secondary sludge	112(102)	2.8
Aerobically digested* sludge haulaway	79(72)	4.0
Concentrated aerobically digested sludge (standby unit)	21(19)	15.0

* Because some concentration of solids occurs within the aerobic sludge digestor, haulaway requirements are lower. A standby unit is available to concentrate the sludge further as required.

Ponding of the sludge is not considered as a disposal alternative since groundwater contamination is possible. Odors, too, could cause nuisance to nearby residents.

The LeSourdsville WTP plans to wet land spread aerobically digested sludge; a standby concentration unit will also be used at times, and the resultant thickened sludge will be landfilled. This practice appears to be acceptable for future operation of the plant.

8.16.1 Landspreading (Wet)

The aerobically digested sludge is suitable for wet land spreading. Although the plant is located in an area that is projected to be urban and suburban, agricultural areas suitable for land spreading are available about 12 round trip miles (19 km) to the northwest.

Although soils in these areas are mostly suitable for spreading, some areas contain soils which are completely unacceptable and they should be avoided. Groundwater availability is also generally low, but care must be taken to avoid use of some areas where groundwater contamination could occur. Slope is generally low and acceptable for land spreading.

Since transport by water or rail is not available and since piping would be uneconomical because of inaccessibility, trucking is the logical means of transport. Estimated trucking costs of $1.20 per wet ton ($1.32/metric ton) are based on hauling 12 miles round trip (19 km) (Ref. VIII-4). Cost for wet land spreading is estimated to be $1.08 per wet ton ($1.19/metric ton)(Ref. VIII-4). Total cost of transport and spreading will be $2.28 per wet ton ($2.51/metric ton). Cost on an annual basis will be $65,744. Of this total, $24,500 is annual amortized capital cost, and $41,244 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $28,800 and $32,500 O&M.

8.16.2 Land Spreading (Dry)

Dry land spreading can be performed in the same agricultural area. Cost of round trip truck transport is estimated to be $1.16 per wet ton ($1.27/metric ton) of concentrated aerobically digested sludge (Ref. VIII-5). Spreading cost is estimated to be $1.31 per wet ton ($1.44/-metric ton) of concentrated aerobically digested sludge (Ref. VIII-10,11). Total cost of transport and dry land spreading is $2.47 per wet ton $2.72/metric ton). Total annual cost for transport and spreading is $18,933 of which $5,700 is amortized capital costs and $13,233 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $32,100 and $35,500 O&M.

8.16.3 Landfilling

The plant proposes to utilize landfilling when the standby sludge concentration unit is operated. The landfill site is about 12 miles (20 km) round trip from the plant. Hauling costs are estimated at $1.16 per wet ton ($1.28/metric ton) (Ref. VII-5). Costs provided by the plant design firm are estimated at $40,000 capital and $5,600 annual operating and maintenance (Ref. VIII-8). If a 20-year life of the landfill is assumed, an annual cost of $16,491 will be incurred, of which $6,300 is annual amortized capital cost and $10,191 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $32,100 and $35,500 O&M.

8.17 CLEVES-NORTH BEND WASTEWATER TREATMENT PLANT (PROPOSED)

Design influent rate for the Cleves-North Bend WTP is 0.5 mgd (1,900 m^3/d). Evaluations are based on daily generation of the following types and quantities of sludge (see Appendix B):

Sludge type	Quantity tons(metric tons)/d	Percent solids
Raw sludge plus return secondary sludge	20(18)	4.0
Aerobically digested sludge	20(18)	4.0
Dewatered aerobic sludge	1.8(1.6)	45.0

Ponding of aerobically digested sludge is considered untenable since little area remains in Hamilton county for such an operation.

The plant proposes to use an on-site landfill to dispose of dewatered aerobic sludge. As long as this practice entails no adverse environmental impacts, it should be acceptable for the future.

8.17.1 Land Spreading (Wet)

The aerobically digested sludge might be land spread in the rural areas to the north and the west of the plant; the most likely site is the area in Dearborn County, where soils, hydrologic characteristics, and slopes are suitable

Distance from the Cleves-North Bend WTP is approximately 10 round trip miles (16 km). Rail or pipeline transport would not be economical for the short distances and small volumes involved. Since no barge transport is available, the optimum method of transport is by truck. Costs for transporting the aerobically digested sludge a 10-mile (16 km) round trip distance are estimated to be \$1.10 per wet ton (\$1.22/metric ton)(Ref. VIII-4). Spreading costs are estimated to be \$1.08 per wet ton (\$1.19/-metric ton) (Ref. VIII-4). Total cost of transport and spreading is estimated to be \$2.18 per wet ton (\$2.40/metric ton). Annual cost would be \$15,914. Of this total \$5,800 is annual amortized capital cost and \$10,114 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of \$4,000 and \$1,000 O&M.

8.17.2 Land Spreading (Dry)

Dewatered sludge can be land spread at the same location. Again, trucking is the only feasible mode of transportation. Cost of transporting the dewatered sludge 10 round trip miles (16 km) is approximately $1.16 per wet ton ($1.28/metric ton)(Ref. VIII-5). Spreading cost is estimated to be $3.58 per wet ton ($3.94/metric ton) of dewatered aerobic sludge (Ref. VIII-10,11). Total cost of transport and spreading would be $4.74 per wet ton ($5.22/metric ton). Total annual cost for transport and spreading will be $3,114 of which $1,800 is amortized capital cost and $1,314 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $8,300 and $1,500 O&M.

8.17.3 Landfilling

Plant operators propose to landfill the dewatered sludge on-site. Costs estimated in design are $4,500 capital and $525 annual operating and maintenance (Ref. VIII-9). If a 20-year life of the landfill is assumed, an annual cost of $725 would be incurred of which $200 would be annual amortized capital cost and $525 is O&M. Applying the methodology to existing WTP process equipment would add an annual amortized capital cost of $8,300 and $1,500 O&M.

Table 8-1 summarizes the total amortized annual capital costs and O&M for all 18 plants.

8.18 REGIONALIZATION OF SLUDGE DISPOSAL

Experience in handling of residuals indicates that economics are usually realized when larger volumes are handled at one location rather than smaller volumes at several. Because this may also be true with sludge handling and disposal, four alternatives have been developed for possible regional sludge handling and disposal: landfilling, barging to a land reclamation site, land spreading, and centralized incineration.

Four transfer stations would service the mid-to-outlying areas of the O-K-I Region. Transfer stations would serve three functions: 1) to consolidate sludge from numerous plants in outlying areas; 2) to provide large-volume dewatering facilities, with resultant processing cost savings, and 3) to provide for transport of dewatered sludge on a volume basis, with probable transport cost savings. The approximate proposed locations and service areas of the transfer stations are shown in Figure 8-2.

First Regional Alternative: Landfill

In the first regional alternative, involving landfill, each transfer station would dewater the sludge from plants in its vicinity and haul it to the central landfill on Este Avenue. Since the Mill Creek WTP is

Table 8-1. DISPOSAL COST SUMMARY FOR O-K-I SAMPLE PLANTS

Land Spread (Wet)

Plant	Unit processes, transportation and ultimate disposal	20 year capital[a] cost ($1,000)	Annual capital cost ($1,000)	Annual O and M cost ($1,000)	Total annual cost ($1,000)
1) Mill Creek WTP	Digestion (Anaerobic)	12,045.0	602.2	92.0	694.3
	Transport (truck)	3,520.0	176.0	189.0	365.0
	Disposal	900.0	45.0	135.0	180.0
Total cost of alternative		16,465.0	823.3	416.0	1,239.3
see pg. 68 *	Digestion[b] (Anaerobic)	12,045.0	602.3	92	694
	Chemical conditioning	2,607.0	130.0	120	250
	Vacuum filtration	1,606.0	80.3	38	118
	Incineration	5,420.0	271.0	81	352
	Transport (truck)	2,380.0	119.0	128	247
	Disposal[c]	600.0	30.0	91	121
Total cost of alternative		24,658.0	1,232.6	550	1,782.6
2) Little Miami WTP	Digestion (Anaerobic)	3,011.0	150.5	19	169.5
	Transport (truck)	2,068.0	103.4	111.2	214.6
	Disposal	400.0	20.0	62.2	82.2
Total cost of alternative		5,479.0	273.9	192.4	466.3
3) Bromley WTP	Transport (truck)[d]	1,318.0	65.9	70.8	136.7
	Digestion (Anaerobic)	4,015.2	200.7	8.0	208.7
	Transport (truck)	370.0	18.5	19.8	38.3
	Disposal	94.0	4.7	14.1	18.8
Total cost of alternative		6,269.5	289.8	112.7	402.5
	Transport (truck)[d]	1,318.0	65.9	70.8	136.7
	Digestion (Anaerobic)	4,015.2	200.7	8.0	208.7
	Chemical conditioning	501.9	25.1	11.0	36.1
	Vacuum filtration	180.7	9.0	5.0	14.0
	Incineration	1,003.7	50.2	14.0	64.2
	Transport (truck)	764.0	38.2	41.1	79.3
	Disposal[c]	194.0	9.7	29.2	38.9
Total cost of alternative		7,977.5	398.8	179.1	577.9
4) Middletown WTP	Digestion (Anaerobic)	1,405.0	70.0	10.0	80.0
	Gravity thickener	201.0	10.0	10.0	20.0
	Transport (truck)	3,640.0	182.0	195.0	377.0
	Disposal	1,002.0	50.1	153.0	203.1
Total cost of alternative		6,248.0	312.1	368.0	680.1
5) Franklin WTP	Transport (pipe) (on-site)	4.0	0.2	3.4	3.6
	Disposal[e]	450.0	22.5	67.7	90.2
Total cost of alternative		454.0	22.7	71.1	93.8
6) Muddy Creek WTP	Air floatation	401.5	20.1	10.0	30.1
	Heat treatment	1,606.1	80.3	90.0	170.3
	Transport (truck)	1,860.0	93.0	100.0	193.0
	Disposal	290.0	14.5	43.5	58.0
Total cost of alternative		4,157.6	207.9	243.5	451.4

Table 8-1 (Cont.). DISPOSAL COST SUMMARY FOR O-K-I SAMPLE PLANTS

Land Spread (Wet) (Cont.)

Plant	Unit processes, transportation and ultimate disposal	20 year capital[a] cost ($1,000)	Annual capital cost ($1,000)	Annual O and M cost ($1,000)	Total annual cost ($1,000)
7) Hamilton WTP	Digestion (Anaerobic)	1,606.0	80.3	11.0	91.3
	Transport (truck)	1,032.0	51.6	55.5	107.1
	Disposal	192.0	9.6	28.9	38.5
Total cost of alternative		2,830.0	141.5	95.4	236.9
8) Sycamore WTP	Digestion (Anaerobic)	200.0	10.0	10.0	20.0
	Gravity thickener	200.0	10.0	10.0	20.0
	Transport (truck)	158.0	7.9	8.5	16.4
	Disposal	50.0	2.5	7.4	9.9
Total cost of alternative		608.0	30.4	35.9	66.3
9) Oxford WTP	Digestion (Anaerobic)	200.0	10.0	10.0	20.0
	Transport (truck)	6.0	0.3	0.3	0.6
	Disposal	4.0	0.2	0.6	0.8
Total cost of alternative		210.0	10.5	10.9	21.4
10) Lawrenceburg WTP	Digestion (Anaerobic)	3,412.0	170.6	24.0	194.6
	Transport (truck)	1,730.0	86.5	92.9	179.4
	Disposal	418.0	20.9	62.7	83.6
Total cost of alternative		5,560.0	278.0	179.6	457.6
11) Bethel WTP	Digestion (Anaerobic)	200.0	10.0	10.0	20.0
	Transport (truck)	28.0	1.4	1.5	2.9
	Disposal	12.0	0.6	1.7	2.3
Total cost of alternative		240.0	12.0	13.2	25.9
12) New Richmond WTP	Digestion (Aerobic)	200.0	10.0	10.0	20.0
	Transport (truck)	40.0	0.2	0.2	0.4
	Disposal	20.0	0.1	0.2	0.3
Total cost of alternative		260.0	10.3	10.4	20.7
13) Felicity WTP	Chemical treatment	200.0	10.0	10.0	20.0
	Transport (truck)	4.0	0.2	0.2	0.4
	Disposal	2.0	0.1	0.3	0.4
Total cost of alternative		206.0	10.3	10.5	20.8
14) Mayflower WTP	Digestion (Aerobic)	200.0	10.0	10.0	20.0
	Transport (truck)	40.0	0.2	0.2	0.4
	Disposal	20.0	0.1	0.1	0.2
Total cost of alternative		260.0	10.3	10.3	20.6
15) SYSTECH	Not applicable, sludge is contributed in Franklin WTP				
16) Dry Creek WTP	Air floatation	1,606.0	80.3	31.0	111.3
	Heat treatment	6,021.6	301.1	275.0	576.1
	Transport (truck)	1,930.0	96.5	103.7	200.2
	Disposal	900.0	45.0	135.1	180.1
Total cost of alternative		10,457.6	522.9	544.8	1,067.7
17) LeSourdsville WTP	Digestion (Aerobic)	576.3	28.8	32.5	61.3
	Transport (truck)	334.0	16.7	17.9	34.6
	Disposal	156.0	7.8	23.4	31.2
Total cost of alternative		1,066.3	53.3	73.8	127.1

Table 8-1 (Cont.). DISPOSAL COST SUMMARY FOR O-K-I SAMPLE PLANTS

Land Spread (Wet) (Cont.)

Alternative	Unit processes, transportation and ultimate disposal	20 year capital[a] cost ($1,000)	Annual capital cost ($1,000)	Annual O and M cost ($1,000)	Total annual cost ($1,000)
18) Cleves North Bend WTP	Digestion (Aerobic)	80.0	4.0	1.0	5.0
	Transport (truck)	76.0	3.8	4.1	7.9
	Disposal	40.0	2.0	5.9	7.9
Total cost of alternative		196.0	9.8	11.0	20.8
Land Spread (Dry)					
1) Mill Creek WTP	Digestion (Anaerobic)	12,045.0	602.0	92.0	694.3
	Chemical conditioning	2,608.0	130.4	120.0	250.4
	Vacuum filtration	1,606.0	80.3	38.0	118.3
	Transport (truck)	1,200.0	60.0	64.5	124.5
	Disposal	110.0	5.5	50.8	56.3
Total cost of alternative		17,569.0	878.5	365.3	1,243.8
2) Little Miami WTP	Digestion (Anaerobic)	3,011.0	150.5	19.0	169.5
	Vacuum filtration	522.0	26.1	19.0	45.1
	Transport (truck)	428.0	21.4	23.0	44.4
	Disposal	38.0	1.9	17.0	18.9
Total cost of alternative		3,999.0	199.9	78.0	277.9
3) Bromley WTP	Transport[d]	1,318.0	65.9	70.8	136.7
	Digestion (Anaerobic)	4,015.2	200.7	8.0	208.7
	Chemical conditioning	501.0	25.1	11.0	36.1
	Vacuum filtration	180.7	9.0	5.0	14.0
	Transport (truck)	128.0	6.4	6.9	13.3
	Disposal	12.0	0.6	5.4	6.0
Total cost of alternative		6,155.8	307.7	107.1	414.8
4) Middletown WTP	Digestion (Anaerobic)	1,405.0	70.0	10.0	80.0
	Gravity thickener	201.0	10.0	10.0	20.0
	Chemical treatment	441,6	22.1	16.0	38.1
	Vacuum filtration	542.0	27.1	19.0	46.1
	Transport (truck)	244.0	12.2	13.1	25.3
	Disposal	54.0	2.7	24.6	27.3
Total cost of alternative		2,887.6	144.1	92.7	236.8
5) Franklin WTP	Not applicable				
6) Muddy Creek WTP	Air floatation	401.5	20.1	10.0	30.1
	Heat treatment	1,606.1	80.3	90.0	170.3
	Vacuum filtration	401.5	20.0	16.0	36.0
	Transport (truck)	320.0	16.0	17.1	33.1
	Disposal	28.0	1.4	8.1	9.5
Total cost of alternative		2,757.1	137.8	141.2	279.0

Table 8-1 (Cont.). DISPOSAL COST SUMMARY FOR O-K-I SAMPLE PLANTS

Land Spread (Dry) (Cont.)

Plant	Unit processes, transportation and ultimate disposal	20 year capital[a] cost ($1,000)	Annual capital cost ($1,000)	Annual O and M cost ($1,000)	Total annual cost ($1,000)
7) Hamilton WTP	Digestion (Anaerobic)	1,606.0	80.3	11.0	91.3
	Vacuum filtration	321.2	16.1	14.0	30.1
	Transport (truck)	60.0	3.0	3.2	6.2
	Disposal	22.0	1.1	8.1	9.2
Total cost of alternative		2,009.2	100.5	36.3	136.8
8) Sycamore WTP	Not applicable				
9) Oxford WTP	Not applicable				
10) Lawrenceburg WTP	Digestion (Anaerobic)	200.0	10.0	10.0	20.0
	Vacuum filtration	200.0	10.0	10.0	20.0
	Transport (truck)	8.0	0.4	0.5	0.9
	Disposal	14.0	0.7	0.5	1.2
Total cost of alternative		422.0	21.1	21.0	42.1
11) Bethel WTP	Not applicable				
12) New Richmond WTP	Not applicable				
13) Felicity WTP	Not applicable				
14) Mayflower WTP	Not applicable				
15) SYSTECH	Not applicable, sludge is contributed to Franklin WTP				
16) Dry Creek WTP	Air floatation	1,606.0	80.3	31.0	111.3
	Heat treatment	6,021.6	301.1	275.0	576.1
	Vacuum filtration	1,405.2	70.3	35.0	105.3
	Transport (truck)	468.0	23.4	25.2	48.6
	Disposal	82.0	4.1	42.5	46.6
Total cost of alternative		9,582.8	479.2	408.7	887.9
17) LeSourdsville WTP	Digestion (Aerobic)	576.3	28.8	32.5	61.3
	Concentration tank	66.7	3.3	3.0	6.3
	Transport (truck)	86.0	4.3	4.6	8.9
	Disposal	28.0	1.4	8.7	10.1
Total cost of alternative		757.0	37.8	48.8	86.6
18) Cleves North Bend WTP	Digestion (Aerobic)	80.0	4.0	1.0	5.0
	Centrifugation	85.0	4.3	0.5	4.8
	Transport (truck)	8.0	0.4	0.4	0.8
	Disposal	28.0	1.4	1.0	2.4
Total cost of alternative		201.0	10.0	2.9	13.0

Landfilling

Plant	Unit processes, transportation and ultimate disposal	20 year capital[a] cost ($1,000)	Annual capital cost ($1,000)	Annual O and M cost ($1,000)	Total annual cost ($1,000)
1) Mill Creek WTP	Digestion (Anaerobic)	12,045.0	602.2	92.0	694.3
	Chemical conditioning	2,608.0	130.4	120.0	150.4
	Vacuum filtration	1,606.0	80.3	38.0	118.3
	Transport (truck)	632.0	31.6	34.0	65.6
	Disposal	3,056.0	152.8	458.3	611.1
Total cost of alternative		19,947.0	997.4	742.3	1,639.7
2) Little Miami WTP	Digestion (Anaerobic)	3,011.0	150.5	19.0	169.5
	Vacuum filtration	522.0	26.1	19.0	45.1
	Transport (truck)	172.0	8.6	9.2	17.8
	Disposal	1,034.0	51.7	155.2	206.9
Total cost of alternative		4,739.0	236.9	202.4	439.3

Table 8-1 (Cont.). DISPOSAL COST SUMMARY FOR O-K-I SAMPLE PLANTS

Landfilling (Cont.)

Plant	Unit processes, transportation and ultimate disposal	20 year capital[a] cost ($1,000)	Annual capital cost ($1,000)	Annual O and M cost ($1,000)	Total annual cost ($1,000)
3) Bromley WTP	Transport[d]	1,318.0	65.9	70.1	136.0
	Digestion (Anaerobic)	4,015.2	200.8	8.0	208.8
	Chemical conditioning	501.9	25.1	11.0	36.1
	Vacuum filtration	180.7	9.0	5.0	14.0
	Transport (truck)	68.0	3.4	3.6	7.0
	Disposal	326.0	16.3	48.8	65.1
Total cost of alternative		6,409.8	320.5	146.5	467.0
4) Middletown WTP	Digestion (Anaerobic)	1,405.0	70.0	10.0	80.0
	Gravity thickener	201.4	10.0	10.0	20.0
	Chemical treatment	441.6	22.1	16.0	38.1
	Vacuum filtration	542.0	27.1	19.0	46.1
	Transport (truck)	244.0	12.2	13.1	25.3
	Disposal	1,478.0	73.9	221.7	295.6
Total cost of alternative		4,312.0	215.3	289.8	505.1
5) Franklin WTP	Not applicable				
6) Muddy Creek WTP	Air floatation	401.5	20.1	10.0	30.1
	Heat treatment	1,606.1	80.3	90.0	170.3
	Vacuum filtration	401.5	20.0	16.0	36.0
	Transport (truck)	268.0	13.4	14.5	27.9
	Disposal	482.0	24.1	72.4	96.5
Total cost of alternative		3,159.1	157.9	202.9	360.8
7) Hamilton WTP	Digestion (Anaerobic)	1,606.0	80.3	11.0	91.3
	Vacuum filtration	321.2	16.1	14.0	30.1
	Transport (truck)	40.0	2.0	2.1	4.1
	Disposal	482.0	24.1	72.4	96.5
Total cost of alternative		2,449.2	122.5	99.5	222.0
8) Sycamore WTP	Not applicable				
9) Oxford WTP	Not applicable				
10) Lawrenceburg WTP	Digestion (Anaerobic)	200.0	10.0	10.0	10.0
	Vacuum filtration	200.0	10.0	10.0	20.0
	Transport (truck)	8.0	0.4	0.5	0.9
	Disposal	52.0	2.6	7.8	10.4
Total cost of alternative		460.1	23.0	28.3	41.3
11) Bethel WTP	Not applicable				
12) New Richmond WTP	Not applicable				
13) Felicity WTP	Not applicable				
14) Mayflower WTP	Not applicable				
15) SYSTECH	Not applicable, sludge is contributed to Franklin WTP				

Table 8-1 (Cont.). DISPOSAL COST SUMMARY FOR O-K-I SAMPLE PLANTS

Landfilling (Cont.)

Plant	Unit processes, transportation and ultimate disposal	20 year capital[a] cost ($1,000)	Annual capital cost ($1,000)	Annual O and M cost ($1,000)	Total annual cost ($1,000)
16) Dry Creek WTP	Air floatation	1,606.0	80.3	31.0	111.3
	Heat treatment	6,021.6	301.1	275.0	576.1
	Vacuum filtration	1,405.2	70.3	35.0	105.3
	Transport (truck)	468.0	23.4	25.2	48.6
	Disposal	2,562.0	128.1	384.3	512.4
Total cost of alternative		12,062.8	603.2	750.5	1,353.7
	Air floatation	1,606.0	80.3	31.0	111.3
	Heat treatment	6,021.6	301.1	275.0	576.1
	Vacuum filtration	1,405.2	70.3	35.0	105.3
	Incineration	5,219.5	260.9	75.0	335.9
	Transport (truck)	64.0	3.2	3.4	6.6
	Disposal[f]	344.0	17.2	51.7	68.9
Total cost of alternative		14,660.3	733.0	471.1	1,204.1
17) LeSourdsville WTP	Digestion (Aerobic)	576.3	28.8	32.5	61.3
	Concentration tank	66.7	3.3	3.0	6.3
	Transport (truck)	86.0	4.3	4.6	8.9
	Disposal	40.0	2.0	5.6	7.6
Total cost of alternative		769.0	38.4	45.7	84.1
18) Cleves North Bend WTP	Digestion (Aerobic)	80.0	4.0	1.0	5.0
	Centrifugation	85.0	4.3	0.5	4.8
	Transport (truck)	On-site; transport cost minimal and included in disposal cost			
	Disposal	4.0	0.2	0.5	0.7
Total cost of alternative		169.0	8.5	2.0	10.5

Disposal Pond

Plant	Unit processes, transportation and ultimate disposal	20 year capital[a] cost ($1,000)	Annual capital cost ($1,000)	Annual O and M cost ($1,000)	Total annual cost ($1,000)
1) Mill Creek WTP	Digestion (Anaerobic)	12,045.0	602.3	92.0	694.3
	Chemical conditioning	2,607.0	130.0	120.0	250.0
	Vacuum filtration	1,606.0	80.3	38.0	118.3
	Incineration	5,420.0	271.0	81.0	352.0
	Transport (pipe; on-site)	4.0	0.2	3.4	3.6
	Disposal	180.0	9.0	26.9	35.9
Total cost of alternative		21,862.0	1,092.8	361.3	1,454.1
2) Little Miami WTP	Digestion (Anaerobic)	3,011.0	150.5	19.0	169.5
	Vacuum filtration	522.0	26.1	19.0	45.1
	Incineration	1,766.0	88.3	30.0	118.3
	Transport (truck)	236.0	11.8	12.7	24.5
	Disposal	130.0	6.5	19.6	26.1
Total cost of alternative		5,665.0	283.2	100.3	383.5

Table 8-1 (Cont.). DISPOSAL COST SUMMARY FOR O-K-I SAMPLE PLANTS

Disposal Pond (Cont.)

Plant	Unit processes, transportation and ultimate disposal	20 year capital[a] cost ($1,000)	Annual capital cost ($1,000)	Annual O and M cost ($1,000)	Total annual cost ($1,000)
3) Bromely WTP	Transport[d]	1,318.0	65.9	70.8	136.7
	Digestion (Anaerobic)	4,015.2	200.7	8.0	208.7
	Chemical conditioning	501.9	25.1	11.0	36.1
	Vacuum filtration	180.7	9.0	5.0	14.0
	Incineration	1,003.7	50.2	14.0	64.2
	Transport (truck)	6.0	0.3	0.8	1.1
	Disposal[c]	58.0	2.9	8.6	11.5
Total cost of alternative		7,083.5	354.1	118.2	472.3
4) Middletown WTP	Digestion (Anaerobic)	1,405.0	70.0	10.0	80.0
	Gravity thickener	201.0	10.0	10.0	20.0
	Vacuum filtration	542.0	27.0	19.0	46.0
	Incineration	1,806.7	90.0	32.0	112.0
	Transport (pipe; on-site)	4.0	0.2	3.4	3.6
	Disposal	50.0	2.5	7.6	10.1
Total cost of alternative		4,008.7	199.7	82.0	271.7
5) Franklin WTP	Transport (truck)	1,128.0	56.4	60.6	117.0
	Disposal[e]	134.0	6.7	20.1	26.8
Total cost of alternative		1,262.0	63.1	80.7	143.8
6) Muddy Creek WTP	Air floatation	401.5	20.1	10.0	30.1
	Vacuum filtration	401.5	20.0	16.0	36.0
	Incineration	1,365.2	68.3	23.0	91.3
	Transport (pipe; on-site)	4.0	0.2	3.4	3.6
	Disposal	46.0	2.3	6.9	9.2
Total cost of alternative		2,218.2	110.9	59.3	170.2
7) Hamilton WTP	Digestion (Anaerobic)	1,606.0	80.3	11.0	91.3
	Transport (truck)	516.0	25.8	27.7	53.5
	Disposal	58.0	2.9	8.6	11.5
Total cost of alternative		2,180.0	109.0	47.3	156.3
8) Sycamore	Not applicable				
9) Oxford WTP	Digestion (Anaerobic)	200.0	10.0	10.0	20.0
	Transport	6.0	0.3	0.3	0.6
	Disposal	2.0	0.1	0.2	0.3
Total cost of alternative		208.0	10.4	10.5	20.9
10) Lawrenceburg WTP	Digestion (Anaerobic)	3,412.0	170.6	24.0	194.6
	Transport (truck)	1,730.0	86.5	92.9	179.4
	Disposal	124.0	6.2	18.6	24.8
Total cost of alternative		5,266.0	263.3	135.5	398.8
11) Bethel WTP	Not applicable				
12) New Richmond WTP	Not applicable				
13) Felicity WTP	Not applicable				

Table 8-1 (Cont.). DISPOSAL COST SUMMARY FOR O-K-I SAMPLE PLANTS

	Disposal Pond (Cont.)				
Plant	Unit processes, transportation and ultimate disposal	20 year capital[a] cost ($1,000)	Annual capital cost ($1,000)	Annual O and M cost ($1,000)	Total annual cost ($1,000)
14) Mayflower WTP	Not applicable				
15) SYSTECH	Not applicable, sludge is contributed to Franklin WTP				
16) Dry Creek WTP	Not applicable				
17) LeSourdsville WTP	Not applicable				
18) Cleves North Bend WTP	Not applicable				

[a] Amortized over 20 years at 8% level debt service.

[b] Digestion process can be eliminated, thus resulting in savings in annual O&M costs. In addition, the incineration process will kill most pathogens.

[c] Disposal of slurried incinerator ash.

[d] Transport of raw sludge from Bromley WTP to Mill Creek WTP.

[e] Disposal of raw industrial sludge.

[f] Disposal of dry incinerator ash.

The mean costs were utilized in calculations rather than the ranges given in the text for landfilling and disposal ponds.

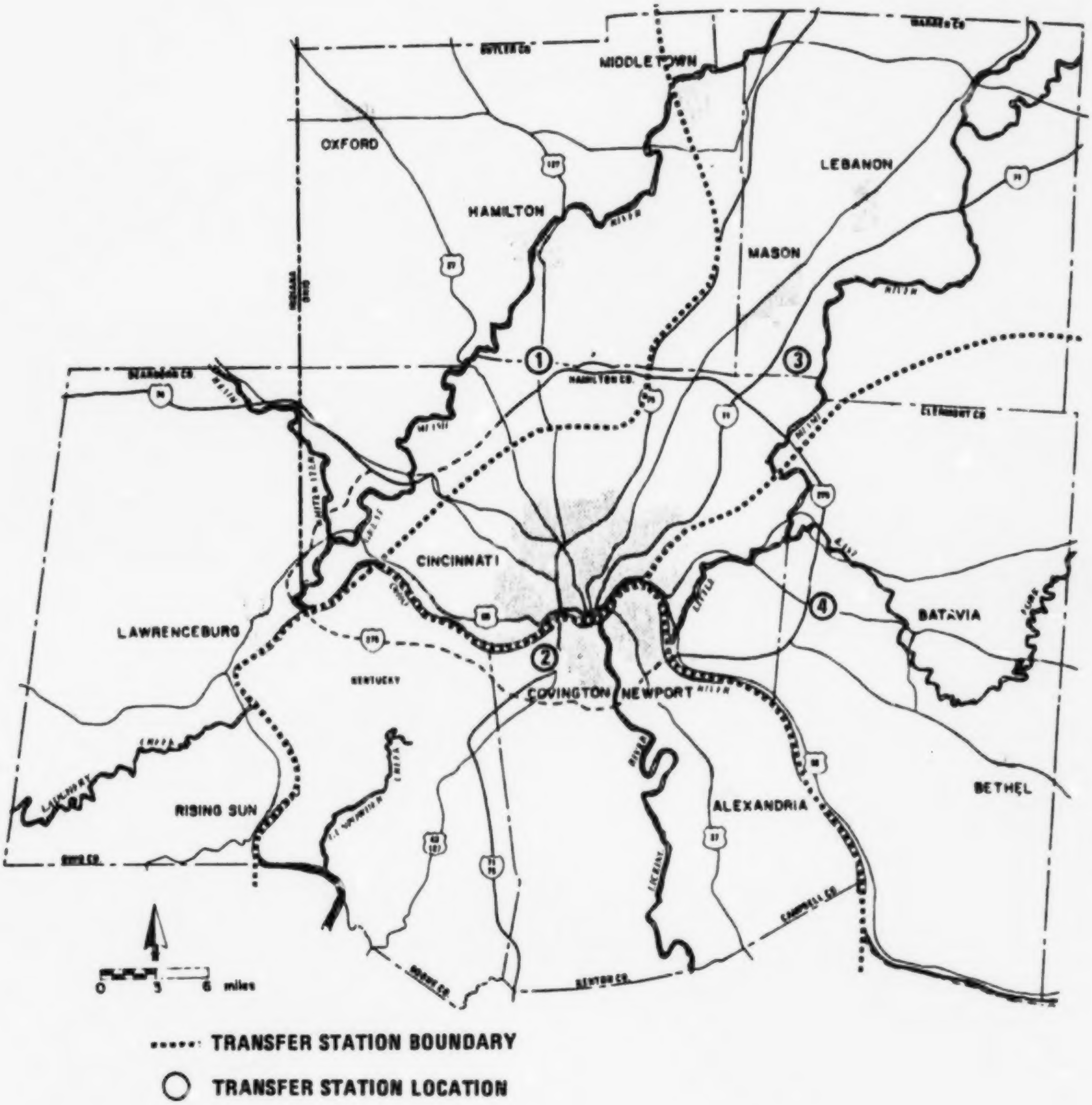

Figure 8-2. Possible transfer station location and service areas.

well established and now vacuum filters sludges in volumes similiar to those of the proposed transfer stations, the Mill Creek plant could operate essentially as its own transfer station. Average round trip hauling distances from treatment plants to transfer stations and from transfer stations to the landfill are listed in Table 8-2.

Table 8-2. AVERAGE HAULING DISTANCES, REGIONAL LANDFILL

Transfer station	Average round trip hauling distance to transfer station, miles (km)	Round trip of distance from transfer station to Este Ave. landfill, miles (km)
1	28 (44)	30 (48)
2	24 (38)	20 (32)
3	28 (44)	32 (52)
4	20 (32)	34 (54)
Mill Creek WTP	not applicable	16 (26)

Each transfer station would be required to vacuum-filter daily the sludge generated in its service area. Table 8-3 lists the approximate daily volumes of sludge (3.5 percent solids assumed) that would be vacuum-filtered at each transfer station and the resulting volumes of filter cake (30 percent solids assumed).

Table 8-3. REGIONAL VOLUMES OF SLUDGE AND FILTER CAKE

Transfer station	Daily volumes of sludge to be filtered, wet tons (metric tons)		Daily volumes of filter cake produced, wet tons (metric tons)	
	1975	1995	1975	1995
1	366 (332)	557 (506)	43 (39)	65 (59)
2	329 (299)	489 (444)	38 (34)	57 (52)
3	700 (636)	1,054 (957)	82 (74)	123 (112)
4	806 (732)	1,208 (1,097)	94 (85)	141 (128)
Mill Creek WTP	455 (413)[a]	1,783 (1,619)	138 (125)	208 (189)

[a] 9.1 percent solids.

Estimated amortized capital and annual operation and maintenance costs for the vacuum filters are given in Table 8-4. Because no sludge transfer station is now in operation, cost data are not available. Since the stations would be similar in principle to transfer stations for solid wastes, capital costs of solid waste transfer stations are entered in the tabulation to indicate the order of magnitude of costs of constructing the sludge transfer stations.

Estimated costs of hauling (wet basis) from the treatment plants to the transfer station and of hauling dewatered sludge from the transfer stations to the landfill are given in Table 8-5.

Cost of landfilling would be approximately \$12.00 to \$15.00 per wet ton (\$13.22 to \$16.52/metric ton) of filter cake. With total daily cake generation in 1995 of 594 wet tons (539 metric tons), a mean annual cost of landfilling would be \$2,926,935 of which \$731,700 is annual amortized capital and \$2,195,235 is O&M. Table 8-9 delineates the total annual amortized capital and O&M for this alternative.

Second Regional Alternative: Barging To Land Reclamation Sites

The transfer stations could also be utilized to consolidate sludge that would be barged down the Ohio River for use in land reclamation at a mining site in Daviess County, Kentucky. Hauling distances from transfer stations to barge facilities and the respective costs are listed in Table 8-6.

Dock and loading facilities would have to be located and constructed. Complete costs for constructing such a facility are unknown. An estimated cost for the installation of five docking cells is \$40,000 per cell or a total of \$200,000 (Ref. VIII-7). This is only a partial cost, however, since other items of cost would be loading and unloading equipment, road access, annual operation and maintenance, and preparation of impact statements required for such an undertaking. A rough estimate of towing costs for the 500-mile round trip (800 km) is \$15.00 per mile (1.6 km)(Ref. VIII-4). Sixty-four trips per year would be required, totaling 32,000 miles (51,200 km), or \$480,000 in barging fees of which \$120,000 is annual amortized capital and \$360,000 is O&M. Reclamation procedures are estimated at 1.22 per wet ton (\$1.34/metric ton) of filter cake or an annual cost of reclamation of \$264,508 of which \$21,900 is annual amortized capital and \$242,608 is O&M (Ref. VIII-10,11). Table 8-9 delineates the total annual amortized capital and O&M for this alternative.

Third Regional Alternative: Land Spreading

The four regional transfer stations could possibly be utilized to consolidate and dewater wastewater treatment plant sludges before transport to a regional dry land spreading site. As stated earlier, an average of 594 wet tons (539 metric tons) of filter cake (30 percent solids) would

Table 8-4. ESTIMATED COSTS OF REGIONAL TRANSFER STATIONS[a]

(values in dollars)

Transfer station	Capital cost of vacuum filters[b]	Annual O&M for vacuum filter[b]	Capital cost of transfer station[c]	Total annual cost[d]
1	863,215	26,000	67,000	72,511
2	782,904	25,000	67,000	67,495
3	1,405,200	36,000	110,760	111,798
4	1,606,080	39,000	110,760	124,842
Mill Creek WTP	2,207,136	48,000	not applicable	158,357

[a] Transfer stations designed to accommodate 1995 daily sludge generation.

[b] Capital costs include either continuous belt or drum type filter, housing, pumps, and equipment for chemical conditioning and biological treatment of the effluent (Ref. VIII-4).

[c] Amortized at 8% over 20 years level debt service (Ref. VIII-5).

[d] Total annual cost = capital cost of vacuum filter/20 yr. life + capital cost of transfer station/20 yr. life + annual O&M for vacuum filter.

Table 8-5. ESTIMATED HAULING COSTS FOR REGIONAL LANDFILL[a]

(values in dollars)

Transfer station	Cost of hauling from WTP's to transfer station[b] per wet ton (metric ton)	Cost of hauling from transfer station to landfill[c] per wet ton (metric ton)	Total annual[d] transport costs
1	1.82 (2.00)	1.07 (1.18)	395,401
2	1.68 (1.86)	0.85 (0.94)	317,539
3	1.82 (2.00)	1.07 (1.18)	748,210
4	1.54 (1.70)	1.07 (1.18)	734,085
Mill Creek WTP	not applicable	0.85 (0.94)	64,532
Total			2,259,767[e]

[a] Estimated using 1995 daily sludge generation rate.

[b] Ref. VIII-4. Includes cost of round trip.

[c] Ref. VIII-5. Includes cost of round trip.

[d] Total annual transport costs = (Round trip hauling costs per wet ton from WTP's to transfer stations x wet tons of sludge (3.5 percent solids) generated per day x 365 days) + (Round trip hauling cost per wet ton of filter cake from transfer station to disposal site x wet tons of filter cake (30.0 percent solids) generated per day x 365 days).

[e] Of this total 1,089,208 is annual amortized capital and 1,170,559 is O&M.

Table 8-6. COSTS OF HAULING TO RIVERFRONT FOR REGIONAL BARGING[a]

Transfer station	Round trip mileage from transfer station to river front, miles (km)	Cost of transport,[b] waiting, and off-loading, $/wet ton ($/metric ton)	Total annual[c] transport cost, dollars
1	44 (70)	1.07 (1.18)	395,401
2	6 (10)	0.64 (0.70)	313,170
3	46 (74)	1.07 (1.18)	748,210
4	32 (54)	1.07 (1.18)	734,085
Mill Creek WTP	6 (10)	0.64 (0.70)	48,589
Total			2,239,455[d]

[a] Estimated using 1995 daily sludge generation rates.

[b] Ref. VIII-5. Includes round trip costs.

[c] Total cost includes transport from wastewater treatment plants to transfer stations and from transfer station to riverfront facilities.

[d] Of this total 1,079,400 is annual amortized capital and 1,160,055 is O&M.

be generated per day in 1995 at the four transfer stations and Mill Creek WTP. This is equal to 216,810 wet tons (196,863 metric tons) per year. A safe long-term application rate of 33 to 66 wet tons per acre per year (74 to 148 metric tons/hectare/yr.) would require 3285 to 6570 acres per year (1331 to 2663 hectare/yr)(Ref. VIII-4). Dearborn County, Indiana, is projected to remain mostly rural and could probably afford the largest single tract of land required for spreading of the filter cake. Access to Dearborn County would be via Interstate 74. As stated earlier, the soils, hydrology characteristics, and slopes in this area appear acceptable for land spreading of filter cake.

Table 8-7 lists average transport distances and costs. Costs include time for travel, waiting, and off-loading (Ref. VIII-5).

The filter cake would be dumped onto the land surface, and then mixed into the soil by disking. Cost of spreading is estimated at $1.18 per wet ton ($1.30/metric ton) of filter cake or an annual cost of spreading of $255,836. Of the total $21,175 is annual amortized capital and $234,661 is O&M. Total annual amortized capital and O&M costs are delineated in Table 8-9.

All three of the regional alternatives thus far discussed require consideration of how and where to store the filter cake during periods of waiting for barge service or during inclement weather that prohibits landfilling or land spreading. It is assumed that barges would be available on a regular basis and that the docking facilities would provide the limited storage capacity required during periods of waiting for barge service. Inclement weather, however, may prevent either landfilling and land spreading for extended periods of time. It is recommended that instead of providing for storage during these periods the filter cake be incinerated at the incinerators now operating in the O-K-I region. The present incinerator capacity in the O-K-I region is sufficient to handle daily filter cake generation up to the year 1995. Therefore, this presents a possible fourth regional alternative.

Fourth Regional Alternative: Centralized Incineration

Utilization of the four regional transfer stations to consolidate and dewater wastewater treatment plant sludges prior to transport to a regional incineration center should also be considered. Mill Creek WTP has several assets which would make it advantageous to serve as the incineration center. It is centrally located in the O-K-I area and is easily accessible by major trafficways. Mill Creek WTP also has four incinerators, each having a capacity of 200 wet tons (182 metric tons) per day, or a total capacity of 800 wet tons (728 metric tons) per day. This capacity is sufficient to handle not only the present daily generation of 395 wet tons (359 metric tons) of filter cake, but also the projected 1995 daily sludge generation of 594 wet tons (539 metric tons)

Table 8-7. COSTS OF TRANSPORT TO LAND SPREADING SITE[a]

Transfer station	Distance round trip, miles (km)	Transport cost,[b] $/wet ton (metric ton)	Daily filter cake generation, wet ton (metric ton)	Total annual transport cost, dollars
1	58 (92)	1.91 (2.10)	43 (39)	415,330
2	70 (112)	2.12 (2.33)	38 (35)	343,962
3	84 (134)	2.54 (2.80)	82 (74)	814,205
4	92 (148)	2.75 (3.03)	94 (85)	820,546
Mill Creek WTP	76 (122)	2.33 (2.57)	138 (125)	176,894
Total				2,570,937[c]

[a] Costs include hauling from WTP's to transfer stations plus transport from transfer station to land spreading site. Transport by 15-ton (13.6 metric ton) trucks is assumed. Estimates derived using 1995 daily sludge generation rates.

[b] Ref. VIII-5; includes round trip costs.

[c] Of this total $1,239,200 is annual amortized capital cost and $1,331,737 is O&M.

of filter cake. Costs of transporting the sludge from the various WTP's to the transfer stations has been listed in Table 8-5. Hauling distances and costs from the transfer stations to Mill Creek WTP are listed in Table 8-8.

Capital cost of an open hearth incinerator is estimated at $16,060,000 amortized at 8 percent over 20 years (Ref. VIII-4). Annual operating and maintenance costs are estimated at $240,000 (Ref. VIII-4). The incineration process will generate an estimated 722,707 wet tons (656,218 metric tons) per year of slurried ash (7.5 percent solids). It is recommended that this slurried ash from the scrubbers be deposited in the ash lagoon on-site. Periodically the lagoon could be cleaned of the ash (25 percent solids assumed) and the ash hauled to the landfill located on Este Ave. An estimated 216,810 wet tons (196,863 metric tons) of lagoon ash would have to be landfilled on an annual basis. Capital cost of lagooning is estimated to range from $0.04 to $0.13 per wet ton ($0.04 to $0.14/metric ton) of slurried ash. Operating and maintenance costs are estimated to range from $0.10 to $0.37 per wet ton ($0.11 to $0.41/metric ton) of ash slurry (Ref. VIII-4). Cost of truck transport of the lagoon ash to the landfill is estimated at $1.45 per wet ton (1.60/metric ton)(Ref. VIII-5). Cost of disposal at the landfill is estimated at $12.00 to $15.00 per wet ton ($13.22 to $16.52/metric ton) of lagoon ash (Ref. VIII-6). Table 8-9 delineates the total annual amortized capital and O&M costs that would be incurred by operating a regional incineration system for wastewater treatment plant sludges in the O-K-I area.

8.19 INSTITUTIONAL ARRANGEMENTS

Responsibilities for sludge management in the O-K-I region are currently fragmented among various sewer districts, and are in some cases further dispersed within these districts. Much more efficient and economical operations can be achieved by reorganization to provide for management on a regional basis or on a subregional basis through two or more of the larger sewer districts. Ideally, direction for formulation of new institutional arrangements will come from the designated 208 planning agency (O-K-I) and the arrangements will coincide with over-all wastewater management in the region. The following sections deal with possible mechanisms for region-wide sludge management and for financing of sludge disposal/recovery operations.

8.19.1 Organizing Sludge Management

As discussed earlier in Section 3.3, numerous sewer districts are now operating in the O-K-I area (Ref. VIII-1). As the only operating agencies responsible for wastewater treatment and sludge management, these districts must be involved in any program for improvement of sludge management. The current fragmented approach probably precludes development of more

Table 8-8. COST OF HAULING TO MILL CREEK WTP FOR REGIONAL INCINERATION

Transfer station	Round trip mileage from transfer station to Mill Creek WTP, miles (km)	Cost of transport,[a] waiting, and off-loading, $/wet ton ($/metric ton)	Total annual transport cost, dollars
1	40 (64)	1.07 (1.18)	259,928
2	10 (16)	0.64 (0.70)	210,620
3	42 (68)	1.07 (1.18)	497,035
4	42 (68)	1.07 (1.18)	489,765
Mill Creek WTP	0 (0)	0.00 (0.00)	0
Total			1,457,348[c]

[a] Ref. VIII-5.

[b] Total cost includes transport from wastewater treatment plants to transfer stations and from transfer station to Mill Creek WTP.

[c] Of this total $702,400 is annual amortized capital costs and $754,948 is O&M.

Table 8-9. DISPOSAL COST SUMMARY FOR THE O-K-I FOUR REGIONAL DISPOSAL ALTERNATIVES

Alternative	Unit processes, transportation and ultimate disposal	20 year capital[a] cost ($1,000)	Annual capital cost ($1,000)	Annual O and M cost ($1,000)	Total annual cost ($1,000)
Landfill	Digestion (Anaerobic)	12,648.0	632.4	85.0	717.4
	Transfer stations and vacuum filtration	7,220.0	361.0	126.0	487.0
	Transport (trucks)	21,784.0	1,089.2	1,170.6	2,259.8
	Disposal[b]	14,635.0	731.7	2,195.2	2,926.9
Total cost of alternative		56,287.0	2,814.3	3,576.8	6,391.1
Barging to land Reclamation Site	Digestion (Anaerobic)	12,648.0	632.4	85.0	717.4
	Transfer stations and vacuum filtration	7,220.0	361.0	126.0	487.0
	Transport (trucks)	21,588.0	1,079.4	1,160.1	2,239.5
	Transport (barge)	2,400.0	120.0	360.0	480.0
	Reclamation	438.0	21.9	242.7	264.6
Total cost of alternative		44,294.0	2,214.7	1,973.8	4,188.5
Landspreading	Digestion (Anaerobic)	12,648.0	632.4	85.0	717.4
	Transfer stations and vacuum filtration	7,220.0	361.0	126.0	487.0
	Transport (truck)	24,784.0	1,239.2	1,331.7	2,570.9
	Disposal	424.0	21.2	234.6	255.8
Total cost of alternative		45,076.0	2,253.8	1,777.3	4,031.1
Incineration	Transfer station and vacuum filtration	7,220.0	361.0	126.0	487.0
	Transport (truck)	14,048.0	702.4	754.9	1,457.3
	Incineration	16,060.0	803.0	240.0	1,043.0
	Disposal of ash to landfill ash lagoon[b]	1,228.0	61.4	169.8	231.2
	Transport of ash (truck)	3,032.0	151.6	162.8	314.4
	Landfill of ash[b]	14,634.0	731.7	2,195.2	2,926.9
Total cost of alternative		56,222.0	2,811.1	3,648.7	6,459.8

[a] Amortized at 8% over 20 year level debt service.

[b] Mean costs of the ranges as stated in text utilized to determine the annual costs.

cost-effective operations, more efficient disposal options, or regional-scale recovery and reclamation techniques. Reorganization would require commitment to change by the operating sewer districts and will necessarily entail intergovernmental arrangements (Ref. VIII-2).

The main intergovernmental mechanisms for consideration for policy makers include: (1) joint operation of sludge collection, transfer, and disposal/utilization by two or more sewer districts; (2) provision of these services on a contractual basis by one sewer district to all others in the O-K-I area; and (3) an overall operating district supervised by a board of directors with day-to-day operation delegated to a manager and staff. Alternative (3) involves creation of yet another single-purpose governmental entity, which in itself may not be cost effective (Ref. VIII-3). On the other hand, dissolution of all existing sewer districts in the O-K-I area and subsequent merging into a single umbrella sewer district would be an ideal institutional arrangement. Such an agency could conduct both wastewater treatment and sludge disposal operations, providing simplified management and probably economies of scale. Immediate implementation would be difficult, however, unless concurrence among the area sewer districts could be achieved quickly.

As options offering similar administrative and economic benefits, alternatives (1) and (2) should be considered.

8.19.2 Enabling Legislation

In the states of Ohio, Kentucky, and Indiana, local units of government and districts may agree under certain circumstances to perform various public services jointly. Generally, agreements can be made to undertake any functions and responsibilities that each unit could perform singly. All three states have enabling legislation, as do most states, providing that public agencies of a state may exercise powers and authorities jointly with other public agencies of the state or public agencies of other states. This legislation allows a broad range of interlocal cooperation and exercise of powers. Typically these shared functions include fire and police protection, hospital service, communications, garbage collection and disposal, water service, wastewater treatment, and waste management. Authorities are broad enough to enable sewer districts in the O-K-I area to implement joint agreements under the following enabling provisions:

Indiana - Interlocal Cooperation Act, Ind.
Ann. Stat., Sec. 53:1101-07 (1957)

Kentucky - Interlocal Cooperation Act., Ky.
Rev. Stat., Sec. 65. 210-300 (1962)

Ohio - Joint Municipal Improvement Act,
Ohio Rev. Code Tit. 7, Sec. 715-02
(1965)

In addition, the Ohio code has provisions that permit Boards of County Commissioners to establish and operate garbage and refuse disposal districts, (County Garbage, and Refuse Disposal Districts, Ohio Rev. Code, Chap. 343). These districts must be financed by self-sustaining modes, such as revenue bonds and user charges. This provision offers a possible mechanism for regional transfer and land disposal of wastewater sludges, perhaps in conjunction with municipal refuse management.

Formulation of a joint operating entity would require designation of a service arm by all of the sewer districts under interlocal enabling provisions of each state. This could be accomplished either by joint establishment of an operating service with adequate financing, staff, equipment, and facilities, or by joint authorization by all sewer districts for one of its members to serve all of them under contract.

8.19.3 Financing

The financing techniques used by the individual sewer districts can be applied to joint operations. User charges might be levied to cover direct operations and to retire revenue bonds used to finance facilities and equipment. Each sewer district would finance the joint operation on a prorated basis depending upon level of service demanded, as determined, for example, by amount of sludge delivered, transport costs, and amount of dewatering required. The joint operation would in effect regionalize costs and income for sludge management without requiring formation of a new regional governmental entity. Some state financing also is legally possible, particularly with regard to capital requirements to implement a regional system. For example, in Ohio, the Water Development Authority is authorized to award bond-generated funds for implementing wastewater treatment and waste management facilities.

A source of funding to provide land for land spreading is authorized under the Federal Water Pollution Control Act Amendments of 1972 (PL92-500) according to a Decision Memorandum issued by the EPA Administrator in late 1975. Federal funds not to exceed 75 percent of land costs may be available for eligible projects considered most cost effective. The cost effectiveness test must precede the Federal funding and not be dependent upon it. Funds can be used for land purchase, but not for land preparation, access roads, buildings, equipment, operations and the like. This funding source has potential for regional application using a joint operating approach as well as for single plant systems. However, the cost effectiveness test may be more easily met through a regional approach.

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Appendix A. WASTEWATER TREATMENT FACILITIES IN O-K-I REGION

Plant No.	County/Plant Name	Plant location	Receiving stream	Design flow (mgd)	Degree of treatment
	Boone County, Kentucky				
1	City of Florence	Rosetta Drive	So. Fork Gunpowder Creek	1.0	Secondary
2	Kenton County Sanitation District #1	Greater Cinti. Airport	Elijahs Creek	0.06	Secondary
3	Boone County	Burlington	Allens Fork	0.005	Secondary
4	Burl Park	Route 18	Allens Fork	0.03	Secondary
5	Little Denmark	Denmark Drive	So. Fork Gunpowder Creek	0.009	Secondary
6	Latonia Race Track	Latonia Race Track	Dry Creek	0.04	Secondary
7	Big Bone Lick State Park	Big Bone Lick State Park	So. Fork Gunpowder Creek	0.04	Secondary
8	Burlington Service Area	Burlington	Allens Fork	0.2	Tertiary
9	Hebron Service Area	Hebron	Upper Woolper Creek	0.3	Tertiary
10	Gunpowder Creek Service Area	Gunpowder Creek West of Florence	So. Fork Gunpowder Creek	2.5	Tertiary
11	Walton Service Area	Needmore Street	Mudlick Creek	0.25	Secondary/ tertiary
	Butler County, Ohio				
12[a]	Middletown Service Area	300 Oxford State Road	Great Miami River	23	Secondary
13	Village of Monroe Service Area	Lawton Street	Shaker Creek	0.25	Secondary
14[a]	City of Hamilton Service Area	2451 River Road	Great Miami River	12	Primary/ secondary
15	City of Fairfield	Groh Lane	Pleasant Run	1	Primary/ secondary
16[a]	Village of Oxford	Juniper Hill Subdivision	Four Mile	9	Primary/ secondary

[a] Sample plants selected for case studies.
N.A. Implies information not available.

Appendix A (continued). WASTEWATER TREATMENT FACILITIES IN O-K-I REGION

Plant No.	County/Plant Name	Plant location	Receiving stream	Design flow (mgd)	Degree of treatment
	Butler County, Ohio (Continued)				
17	County Operated Systems	Cinti.-Dayton Rd. & I-75	East Branch Mill Creek	0.25	Primary
18	County Operated Systems	Port Union	East Branch Mill Creek	0.05	Secondary
19	County Operated Systems	Normandy Heights Ravenna Drive	Great Miami River	0.08	Secondary
20	County Operated Systems	Vanda Drive	Great Miami River	0.02	Secondary
21	County Operated Systems	Black Road	Indian Creek	0.12	Secondary
22	County Operated Systems	Bonham Road	Four Mile	N.A.	Primary
23	New Miami Plant	Sipps Lane, New Miami	Great Miami River	0.12	Secondary
24[a]	Lesourdsville Reg. Wastewater Treatment	S.R. #4 at Lesourdsville	Great Miami River	4.0	Tertiary
25	Lakota Hills STP	7375 Maud-Hughes Road Union Township	Gregory Creek	0.075	Tertiary
26	Brentwood Estate Sewage Treatment	Mindy Drive, Fairfield Township	Unnamed tributary of Great Miami River	0.045	Tertiary
27	Hunting Creek Sewage Treatment Plant	Princeton Pike, Liberty Township	Hunts Creek, Gregory Creek, Great Miami River	0.075	Tertiary
28	Dutchland Woods Sewage Treatment Plant	Hansbrinker Ct., Liberty Township	Hunts Creek, Gregory Creek, Great Miami River	.080	Tertiary
29	Greenview North Sewage Treatment Plant	Hogue Road, Hanover Township	Four Mile Creek	0.07	Tertiary
30	Millville Sewage Treatment Plant	Hanover/Ross Township	Indian Creek	N.A.	Primary

[a] Sample plants selected for case studies.
N.A. Implies information not available.

Appendix A (continued). WASTEWATER TREATMENT FACILITIES IN O-K-I REGION

Plant No.	County/Plant Name	Plant location	Receiving stream	Design flow (mgd)	Degree of treatment
	Butler County, Ohio (Continued)				
31	Alamo Heights STP	Stahlneber Road & Jean Drive, Hanover Twp.	Two Mile Creek	0.027	Tertiary
32	Morris Hill Sewage Treatment Plants	Dust Commander Drive, Fairfield Twp.	Mill Creek	0.10	Tertiary
33	West Chester Woods Sewage Treatment Plant	Barrett Road, Union Township	Branch of East Fork of Mill Creek	0.15	Tertiary
34	Southwestern Union Twp.	Port Union	Mill Creek	0.052	Tertiary
35	Arborcrest - Cloverdale STP	Princeton Pike & Liberty, Fairfield Rd.	Mill Creek	0.06	Tertiary
36	Highland Greens STP	North of I-75, Union Twp.	East Fork of Mill Creek	0.25	Tertiary
37	Lakota High School	5050 Tylersville Rd., West Chester	Unnamed tributary of Mill Creek	0.04	Tertiary
38	Rolling Knolls STP	North of S.R. #42, Union Twp.	Branch of Mill Creek	0.0325	Tertiary
39	Gettysburg Estates Mobile Home Park	8600 Columbus-Cincinnati Rd., West Chester	East Fork of Mill Creek	0.03	Tertiary
40	Mill Run Farm STP	Tylersville Rd. & S.R. #747, Union Twp.	Unnamed Branch of Mill Creek	0.07	Tertiary
41	Woods Sewage Treatment	Hickory-Hill Lane	East Fork	0.15	Tertiary
	Campbell County, Kentucky				
42	Crestview Sanitary District No. 2	Dodsworth Lane	Uhl Creek	0.07	Secondary
43	Brookwood Estates	Ky. 10 South of persimmon grove intersection	Brush Creek	0.1	Secondary
	Clermont County, Ohio				
44	Halls Run (PUB Subdistrict)	Summerside Road	Halls Run	0.50	Secondary
45	Shayler Run (PUB Subdistrict)	St. Route #32	Shayler Run	0.50	Secondary
46	Viking Village (PUB Subdistrict)	Glenrose Lane	Dry Run	0.125	Secondary

Appendix A (continued). WASTEWATER TREATMENT FACILITIES IN O-K-I REGION

Plant No.	County/Plant Name	Plant location	Receiving stream	Design flow (mgd)	Degree of treatment
	Clermont County, Ohio (Continued)				
47	Withamwoods (PUB Subdistrict)	Winding Way	Ninemile Creek	0.120	Secondary
48	Summerside (PUB Subdistrict)	Summerside Road	Halls Run	0.080	Secondary
49	Amelia-Batavia[1] (PUB Subdistrict)	Foundry Ave. extended	East Fork	4.66 → 9.23	Secondary
50	Miami System (MGS Subdistrict)	U.S. 50 at Sugar Camp Rd.	East Fork	0.80	Secondary
51	Owensville System (MGS Subdistrict)	Route 132	Stonelick Creek	0.12	Secondary
52	Longfield Acres Subdivision	S.R. #131	Sugar Camp Creek	0.06	Secondary
53	Milford	Bay Road	East Fork	0.60	Secondary
54	Batavia	Foundry Avenue	East Fork	0.20	Secondary
55	Williamsburg	Second Street	East Fork	0.35	Secondary
56[a]	Bethel	W. Osborn St.	Town Run	0.52	Secondary
57[a]	New Richmond	Old U.S. 52	Ohio River	0.40	Secondary
58	Indian Lookout	Ryan Circle	Trib. Little Miami River	0.014	Secondary
59	Clermont County Sewer District	Halls Run at East Fork	East Fork	3.96 → 7.78[1]	Secondary/tertiary
60	Clermont County Sewer District	O'Bannon Creek	O'Bannon Creek	0.36 → 0.72[1]	Secondary/tertiary
61	Clermont County Sewer District	Marathon	Upper East Fork, Little Miami River	0.03	Secondary/tertiary
62	Clermont County Sewer District	Ninemile at U.S. 52	Nine Mile Creek	0.6 → 1.1[1]	Secondary

[1] Proposed 1976-1990 projects.

[a] Sample plants selected for case studies.

Note: → Indicates expansion of plant capacity.

Appendix A (continued). WASTEWATER TREATMENT FACILITIES IN O-K-I REGION

Plant No.	County/Plant Name	Plant location	Receiving stream	Design flow (mgd)	Degree of treatment
	Clermont County, Ohio (Continued)				
63	Village of Neville	Neville U.S. 52	Ohio River	0.03	Secondary
64	Village of Newtonsville	Newtonsville	Upper East Fork of Little Miami River	0.04	Secondary/tertiary
65	County-MG 3 Water Sub-district	By-pass 50 and 126, Miamiville, Ohio	Little Miami River	0.60	Primary
66	Wiliamsburg Sewage Plant	Williamsburg	Little Miami River	0.25	Secondary
67	Batavia Sewage Treatment Plant	Haskell Lane, Batavia	East Fork Little Miami	0.150	Secondary
68	Amelia-Batavia Wastewater Treatment Plant	Haskell Lane, Batavia	East Fork Little Miami	1.2	Secondary
69	Arrowhead Park Sewage Treatment Plant	Bridge St., Branch Hill	Little Miami River	0.14	Tertiary
70	Stonelick Creek Sewage Treatment Plant	S.R. 132, North of U.S. 50	Stonelick Creek	0.12	Secondary
71	Oak Knolls Estate Sewage Treatment Plant	Rolling Knolls Dr., Goshen Township	Unnamed branch of O'Bannon Creek	0.08	Tertiary
72	Goshen Schools Sewage Treatment Plant	Goshen Road, Goshen	Tributary of O'Bannon Creek	0.07	Tertiary
73	Gaslight Village Mobile Home Park	S.R. 28, Goshen	O'Bannon Creek	0.08	Tertiary
74	PUB Water Subdistrict	S.R. 749, New Richmond	Nine Mile Creek	0.4	Secondary
75[a]	Felicity Sewage Treatment Plant	Prather Road, Felicity	Bear Creek	0.20	Secondary
76	Hilltop Estates Mobile Home Park	S.R. 132, New Richmond	Fagin Run to Twelve-Mile Drive	0.03	Tertiary

[a] Sample plants selected for case studies.

Appendix A (continued). WASTEWATER TREATMENT FACILITIES IN O-K-I REGION

Plant No.	County/Plant Name	Plant location	Receiving stream	Design flow (mgd)	Degree of treatment
	Dearborn County, Indiana				
77	Aurora Utilities	Manchester Street	Hogan Creek	0.85	Primary
78[a]	Lawrenceburg Utilities	Durbin Road	Ohio River	1.5	Secondary
79	Town of Dillsboro	Dillsboro	Laughery Creek	0.10	Secondary
80	Town of Moores Hill	Moores Hill	Hogan Creek	0.11	Secondary
81	So. Dearborn Regional Sewer District	West of Tanners Creek and So. of U.S. 50	Tanners Creek	3.16	Secondary
82	Bright	Bright	Miami-Whitewater	0.05	Secondary
83	Lake Dilldear	U.S. 50 and Dearborn-Ripley County Line	Laughery Creek	0.05	Secondary
84	Greendale Utilites	Probasco Avenue	Tanners Creek	0.37	Primary
	Hamilton County, Ohio				
85	Harrison (Not MSD)	Campbell Road	Whitewater	0.85	Primary
86[a]	Cleves (Not MSD)	Harbor Drive	Ohio River	0.50	Primary
87	Shady Lane Park	Quadrant Road	Ohio River	0.070	Secondary
88[a]	Muddy Creek	River Road	Ohio River	15.0	Primary
89	Audubon Woods	Race Road	Taylor Creek	0.084	Secondary
90	West Fork Acres	Sombero Court	Taylor Creek	0.035	Secondary
91	White Oak Estates	Jessop Road	Briarly Creek	0.035	Secondary
92	Monfort Heights	Audro Drive	Taylor Creek	0.025	Secondary
93	Frontier Park	Timberpoint Drive	Taylor Creek	0.048	Secondary
94	Brunswick Village	Benhill Drive	Briarly Creek	0.035	Secondary
95	Oakhollow Estates	Oak Meadow Lane	Briarly Creek	0.033	Tertiary
96	Colerain Heights	Springdale Road	Blue Rock Creek	0.180	Secondary

[a] Sample plants selected for case studies.

Appendix A (continued). WASTEWATER TREATMENT FACILITIES IN O-K-I REGION

Plant No.	County/Plant Name	Plant location	Receiving stream	Design flow (mgd)	Degree of treatment
	Hamilton County, Ohio (Continued)				
97	Northbrook	Capstan Drive	Blue Rock	0.035	Secondary
98[a]	Mayflower Estates	Overdale Drive	Banklick	0.080	Tertiary
99	Kingsbridge	John Gray Road	Pleasant Run	0.09	Secondary
100	Kempermill Village	John Gray Road	Pleasant Run	0.20	Tertiary
101[a]	Mill Creek	1600 Gest St.	Ohio River	240	Secondary
102[a]	Little Miami	Kellogg & Wilmer	Ohio River	45.0	Secondary
103	Glendale (Not MSD)	Sharon Road	Mill Creek	0.60	Secondary
104[a]	Sycamore	Remington Road	Sycamore Creek	5.0	Secondary
105	Loveland (Not MSD)	Harper Avenue	Little Miami	0.375	Secondary
106	Loveland (Not MSD)	E. Kemper Road	Little Miami	1.00	Secondary
107	River Hills (Not MSD)	River Hills Drive	Unnamed creek	N.A.	Secondary/tertiary
108	Wayside Hills	Shady Hollow Court	Unnamed creek	0.023	Secondary
109	Four Mile	Kellogg	Ohio River	0.50	Primary
110	Watch Hill 5th	Bennett Road	Five Mile Creek	0.017	Secondary
111	Cold Stream Farms	Five Mile Road	Five Mile Creek	0.026	Secondary
112	Britney Acres	Asbury Road	Five Mile Creek	0.15	Secondary
113	Mountain Brood	Pinecreek Drive	Eight Mile	0.0196	Secondary
114	Dry Run	Forest Lake Drive	Dry Run Creek	0.60	Secondary
115	Washington Hills	Senate Court	Dry Run Creek	0.053	Tertiary
116	Viking Village (MSD)	Glenrose Lane	Dry Run Creek	0.125	Secondary
117	Taylor Creek	Colerain Township	Great Miami River	5.0	Tertiary

[a] Sample plants selected for case studies.
N.A. Implies information not available.

Appendix A (continued). WASTEWATER TREATMENT FACILITIES IN O-K-I REGION

Plant No.	County/Plant Name	Plant location	Receiving stream	Design flow (mgd)	Degree of treatment
	Hamilton County, Ohio (Continued)				
118	Cleves	North Miami Ave.	Great Miami River	0.41	Primary
119	Westbrook Village Mobile Home Park	Hamilton-Cleves Pike	Roadside ditch to unnamed tributary of Great Miami	0.05	Secondary
120	Fox Run Mobile Home Park	825 Hamilton-Cleves Pike	Ditch tributary to Great Miami	0.04	Tertiary
121	Pleasant Run Jr. High	1170 Pipin Road	Unnamed Creek	0.0032	Tertiary
122	Pleasant Run Elementary	11765 Hamilton Ave.	Pleasant Run Creek	0.015	Secondary
123	Oakview Estates	7581 Appleridge Court	Steel Creek	0.05	Tertiary
124	Millwood Wastewater Treatment Plant	11256 Brookridge Dr.	North Branch Creek	0.03	Tertiary
125	Commonwealth Park STP	7308 Eglington Court	Branch of Clough Creek	0.08	Tertiary
126	Northeast Knolls STP	Sycamore Township	Sharon Creek	0.022	Tertiary
	Kenton County, Kentucky				
127	Quail Hollow	Lakeside Park of U.S. 25	Unnamed tributary of Horse Branch Creek	0.02 (1) 0.03 (2)	Secondary
128	Summit Hills #2	Dudley Pike and Ky. 17 Intersection	Banklick Creek	0.06	Secondary/tertiary
129	Summit Hills #1	Dudley Pike	Banklick Creek	0.15	Secondary
130	Pius Heights	Dudley Pike	Bullock Pen Creek	0.08	Secondary
131	Elsmere	Turkeyfoot Road	Bullock Pen Creek	1.08	Secondary
132	Ft. Mitchell	Dixie Highway	Unnamed tributary of Pleasant Run Creek	0.125	Secondary
133	Park Hills	Hollow Road (Ky. 1072)	Unnamed tributary of Pleasant Run Creek	0.18	Secondary

Appendix A (continued). WASTEWATER TREATMENT FACILITIES IN O-K-I REGION

Plant No.	County/Plant Name	Plant location	Receiving stream	Design flow (mgd)	Degree of treatment
	Kenton County, Kentucky (Continued)				
134[a]	Bromley	Ky. 8 at Bromley	Ohio River	40.0	Primary
135[a]	Dry Creek	High Water Road	Dry Creek	30	Secondary
	Ohio County, Indiana				
136	Rising Sun Utilities	State Route 56	Ohio River	0.18	Primary
	Warren County, Ohio				
137	Lebanon	Glosser Road	Turtle Creek	0.75	Secondary
138	Mason	Main Street	Muddy Creek	0.75	Secondary
139	Mason	Brookview Drive	Muddy Creek	N.A.	N.A.
140	South Lebanon	Mason Road	Dry Run	0.03	Secondary
141	Springboro	Lower Springboro Rd.	Clear Creek	0.60	Secondary
142	Waynesville	Route 73	Little Miami	0.20	Primary
143[a]	Miami Conservatory District	Franklin	Great Miami River	23.0	Secondary
144	Knollbrook Meadows	S.R. 122	Dick's Creek	0.07	Secondary
145	Lebanon-Deerfield Sewer District	Union Road, Monroe	Shaker Creek	0.50	Primary
146	Waynesville Sewage Treatment Plant	S. Water Street	Little Miami River	0.4	Secondary

[a] Sample plants selected for case studies.
N.A. Implies information not available.

Appendix A (continued). WASTEWATER TREATMENT FACILITIES IN O-K-I REGION

Plant No.	County/Plant Name	Plant location	Receiving stream	Design flow (mgd)	Degree of treatment
	Warren County, Ohio (Continued)				
147	(Proposed) Southwest Warren County Regional	Deerfield Township	Muddy Creek	5.0	Secondary/ tertiary
148	Hamilton-Deerfield	Striker Road	Little Miami River	0.025	Secondary/ tertiary
149	Harlan-East Fork Water System	Pleasant Plain	Little Miami River		Primary
150	Lebanon Correctional Inst.	S.R. 63	Shaker Creek	0.60	Secondary
151	Warren County Garage and Office Bldg. Sewage Treatment Plant	105 Markey Road	Tributary to Turtle Creek	.005	Secondary
152	Kings Mills Subdistrict STP	Deerfield Township	Little Miami River	0.3	Tertiary
153	Viking Village STP	Glen Rose Lane	Dry Run	0.125	Secondary
154	Deerfield-Hamilton Plant		Deerfield-Hamilton	4.3 + 6.7^1	Secondary/ tertiary
155[a]	Franklin (Systech)	Franklin, Ohio	Great Miami	0.04	Industrial plant
156	Harveysburg Treatment Plant	Harveysburg, Ohio	Caesar Creek	0.3 + 0.1^1	Primary
157	Mason-South Lebanon	Kings Mills, Ohio	Muddy Creek	8.5 + 35.5^1	Tertiary
158	Morrow Treatment Plant	Morrow, Ohio	Central Little Miami River	1.5 + 2.7^1	Primary

[1] By 1990.

[a] Sample plants selected for case studies.

N.A. Implies information not available.

+ Indicates expansion of plant capacity.

Source: Ohio-Kentucky-Indiana Regional Council of Governments, Cincinnati, Ohio.

APPENDIX B TREATMENT PLANT CASE STUDIES

B.1 MILL CREEK WASTEWATER TREATMENT PLANT (Ref. B-1)

The Mill Creek Wastewater Treatment Plant, the largest plant in the O-K-I Region, is operated by the Metropolitan Sewer District (MSD) of Greater Cincinnati. It is located on Gest Street in Cincinnati, Ohio. The plant serves the greater part of the residential and commercial sections of the city together with the industrialized Mill Creek Valley, which houses a large variety of industries, both in size and type of manufacturing operation. Some of the major industries that contribute significantly to the load of the treatment plant are chemical processors, metal fabrication, food processors, and electronics. Very few industries pretreat wastewaters in any way, and it is generally not known what kind of pretreatment, if any, is performed. Currently, the plant provides only primary treatment, but construction is well underway to expand the facility to provide secondary treatment by 1977.

General Facility Description

Current flow of influent	120 mgd (456,000 m^3/d)
Design flow (with secondary treatment)	240 mgd (912,000 m^3/d)
Current population served	500,000
Design population	Stable

Liquid Treatment (Figure B-1)

Wastewater from the Mill Creek interceptor and the Ohio River interceptor sewers pass through bar screens spaced 3 inches apart. The objects caught in the bars are mechanically raked off, ground into small pieces, and returned to the wastewater. Objects that cannot be ground are removed and disposed of in a landfill.

The wastewater then flows into a wet well, from which it is pumped into a prechlorination chamber. All raw waste is prechlorinated to destroy odor-producing compounds. Prior to primary clarification, the wastewater flows into a grit chamber. The clarified effluent is postchlorinated and discharged into the Ohio River.

When secondary treatment facilities are completed, the effluent from the primary clarifier will flow into aeration tanks and then into secondary settling tanks. The effluent will be postchlorinated and discharged into the Ohio river.

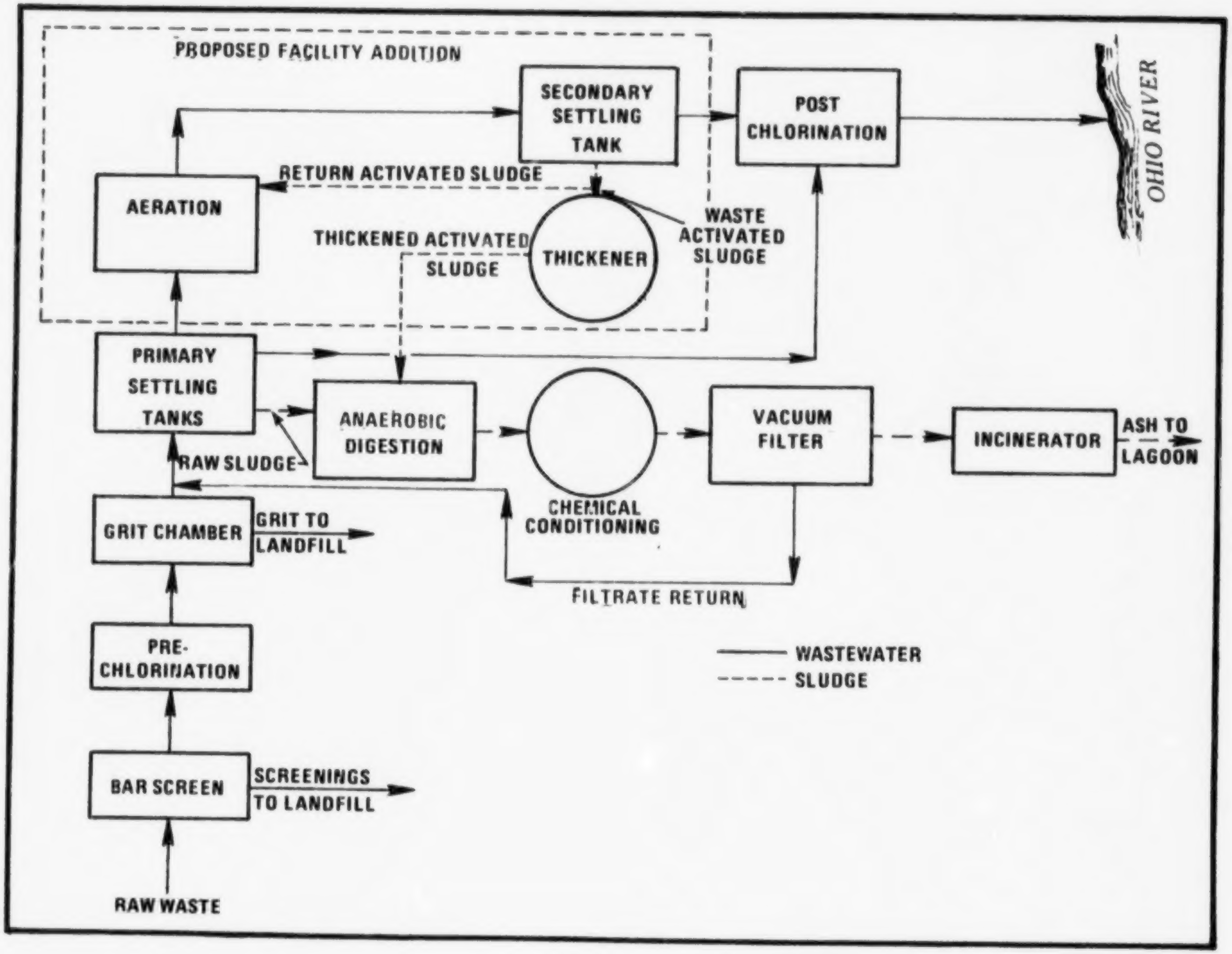

Figure B-1. Flow diagram for Mill Creek wastewater treatment plant.

Solids Handling

Daily production of raw sludge at 5 percent solids totals 1,987 wet tons (1804 metric tons).

Anaerobic Digestors

Ten digestor tanks, each of 2.33 million gallons (8,820 m^3) capacity are provided. Currently six tanks are in operation; each tank is loaded at 80,000 to 90,000 gallons (304 to 342 m^3) per day, with an average detention time of 25 days. The digestors produce an average of 1.2 million cubic feet (34,000 m^3) of gas per day. The plant has no facility for storage of this gas, but it is used in the plant for the production of power and in the incinerators. Solids content of the sludge leaving the digestors is reduced to 9.3 percent.

Sludge Holding Tanks

Four holding tanks, each of 346,000 gallon (1,315 m^3) capacity, are provided. The tanks are designed for a detention time of 5.1 hours. The holding tanks permit periodic rather than continuous removal of digested sludge from the digestors for the elutriation system.

Elutriation

The digested sludge is mixed with effluent from the primary settling tank to enhance removal of certain compounds that inhibit filtration of the sludge.

Chemical Conditioning and Vacuum Filtration

Two pounds (0.91 kg) of polyelectrolyte are used per ton (0.9 metric ton) of dry solids in the elutriated sludge prior to vacuum filtration.

Eight vacuum filters, each with 500 square feet (46.5 m^2) of filter cloth, are provided. Currently three filters are in use. The filters are loaded at a rate of 2.5 pounds per square foot per hour, (12.3 $kg/m^2/hr$) to yield a filter cake with 33 percent solids.

Incineration

Four multiple-hearth incinerators are provided, but only one is operating. Approximately 23 dry tons (20.8 metric tons) of ash are produced each day. The ash is slurried with scrubber water and ultimately disposed to ash lagoons located nearby.

B.2 LITTLE MIAMI WASTEWATER TREATMENT PLANT (Ref. B-2)

The Little Miami Plant, operated by the MSD of Greater Cincinnati, is the second largest in Hamilton County. It is located on Wilmer Avenue and serves the eastern section of the MSD, mostly a residential-commercial community. One paper mill contributes some pollution to the plant. The plant is being up-graded to provide secondary treatment by 1977.

General Facility Description

Current flow of influent	31 mgd (117,800 m^3/d)
Design flow	45 mgd (171,000 m^3/d)
Current population served	170,000
Design population	Not known

Liquid Treatment (Figure B-2)

Raw wastewater from the Little Miami interceptor and the Delta Avenue force main flows through a bar screen to a grit chamber. From the grit chamber, the wastewater flows through the chemical building, where chemicals can be added if needed. The wastewater is clarified in the primary clarifier, and its effluent is then chlorinated prior to discharge into the Ohio River.

When construction for the secondary treatment facility is completed, biological treatment will be provided by use of aeration tanks and secondary clarifiers.

Solids Handling

Daily production totals 417 wet tons (379 metric tons) of raw sludge at 5 percent solids.

Sludge Holding Tanks

The present anaerobic digestors are used as holding tanks, which retain the sludge for about 20 days. About 250 wet tons (227 metric tons) per day (260 day/year basis) of raw sludge at 6 percent solids are hauled to Mill Creek Wastewater Treatment Plant, where the sludge is dewatered and incinerated.

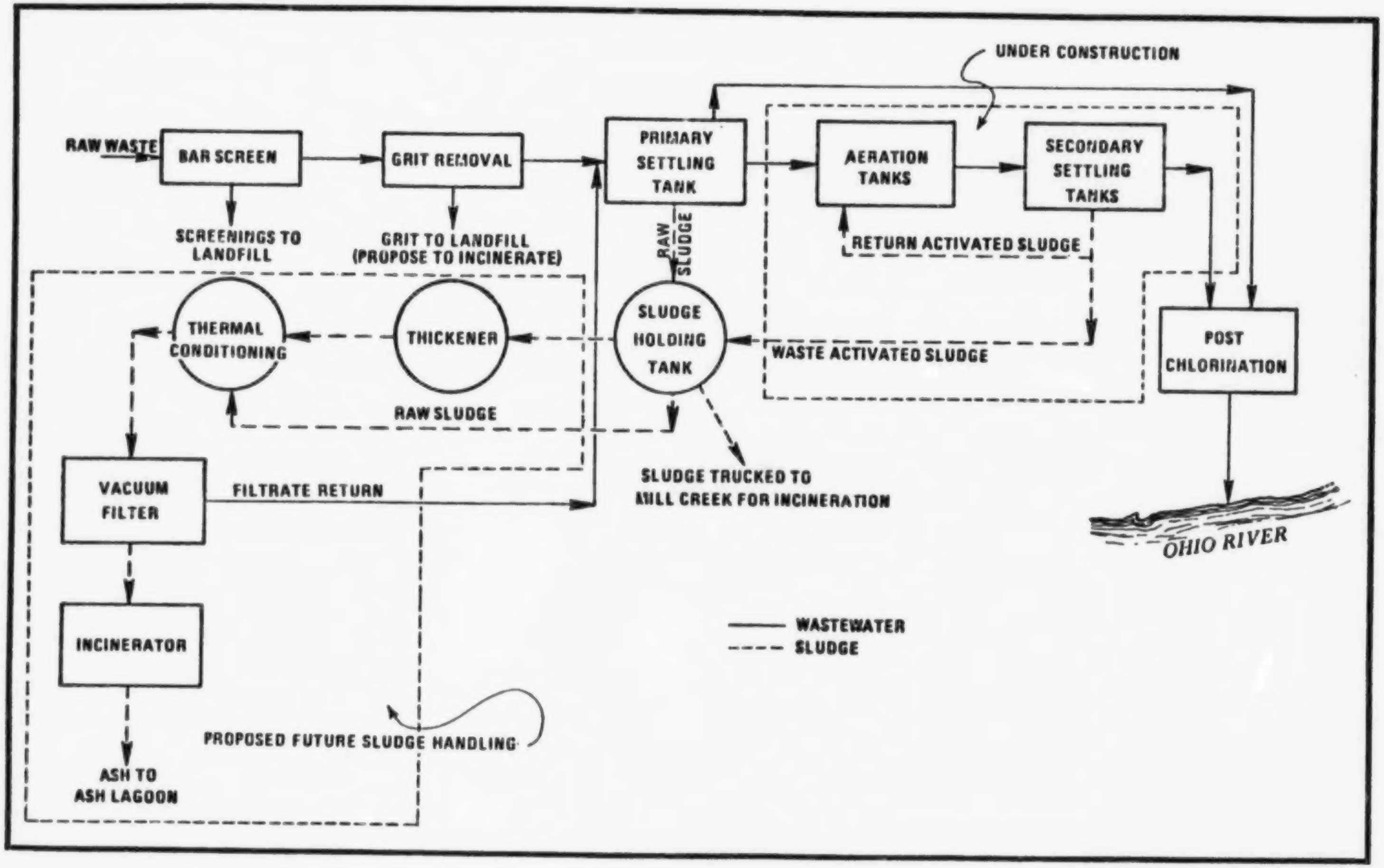

Figure B-2. Flow diagram for Little Miami wastewater treatment plant.

Proposed Sludge-Handling Facility

The plant is equipped with an anaerobic digestor with gas storage facility, a vacuum filter, and an incinerator. None of these units is currently in use.

With completion of secondary treatment facilities, now under construction, the plan is to install four vacuum filters and two incinerators, which will be adequate to handle the expected sludge production. Three ash lagoons are to be located within 2 miles (3.2 km) of the plant, each with a projected life of 25 years.

B.3 SANITATION DISTRICT NO. 1 OF CAMPBELL AND KENTON COUNTIES. NORTHERN KENTUCKY (BROMLEY WASTEWATER TREATMENT PLANT) (Ref. B-3)

Sanitation district No. 1, Campbell and Kenton Counties operates the Bromley, Northern Kentucky, Wastewater Treatment Plant, which serves a community about 70 percent residential-commercial and 30 percent industrial. Some of the major industries discharging process water into the plant are distillaries and breweries, slaughterhouses, and plating and textile plants. None of these provides any kind of pretreatment.

The Bromley treatment facilities will be phased out in 1977, when construction of the new plant at Dry Creek is completed. The present site will be converted into a lift station.

General Facility Description

Current flow of influent	20.8 mgd (79,040 m^3/d)
Design flow	40 mgd (152,000 m^3/d)
Current population served	170,000
Design population	Not known

Liquid Treatment (Figure B-3)

The influent enters a grit chamber, where it can be prechlorinated if needed. From the grit chamber it flows to the pump house, where it is pumped to a comminutor. Most of the suspended solids settle out in the primary settling tanks before the effluent is discharged into the Ohio River.

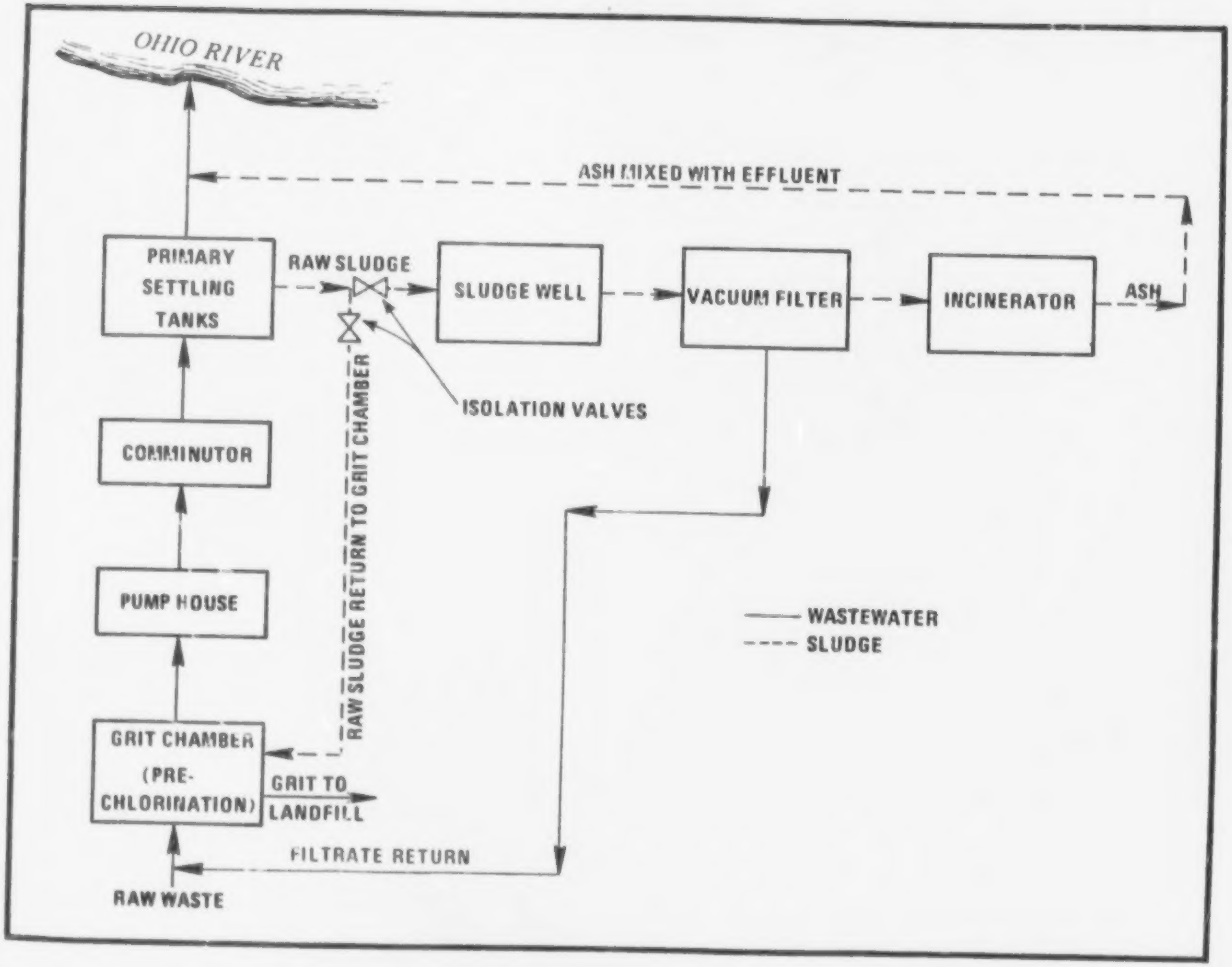

Figure B-3. Flow diagram for Bromley wastewater treatment plant.

Solids Handling

Daily production is 197 wet tons (179 metric tons) of raw sludge at 3.8 percent solids. All of the raw sludge is either returned to the grit chamber or pumped to the sludge well, where it undergoes dewatering followed by incineration. Plant operators alternate these systems every 3 or 4 days.

Vacuum Filtration

There are two vacuum filters, each with an area of 377 square feet (35 m^2). One filter serves as a backup. The filter is loaded at a rate of 3.25 pounds per square foot per hour (15.9 $kg/m^2/hr$) to produce 19.4 wet tons (17.6 metric tons) per day of filter cake at about 38 percent solids. Maximum capacity of the filters is 4.4 pounds per square foot per hour (21.5 $kg/m^2/hr$).

Incineration

One multiple-hearth incinerator yields 1,650 pounds (749 kg) of dry solids per hour. The incinerator is typically loaded at 1228 pounds (550 kg) per hour and produces 450 pounds of ash (206 kg) per hour. The ash is mixed with the final effluent and discharged into the Ohio River.

B.4 MIDDLETOWN WASTEWATER TREATMENT PLANT (Ref. B-4)

The Middletown Wastewater Treatment Plant is located on Oxford State Road, in Middletown, Ohio. The City of Middletown is responsible for the operation of the plant. Three-fourths of the total load to the plant is residential and commercial and the rest is industrial. The major industries served are paper mills, plating and steel.

General Facility Description

Current flow of influent	10 mgd (38,000 m^3/d)
Design flow	23 mgd (87,400 m^3/d)
Current population served	55,000
Design population	90,000

Liquid Treatment (Figure B-4)

Wastewater flows through bar screens and a grit chamber before entering the primary settling tanks. Clarified effluent from the primary set-

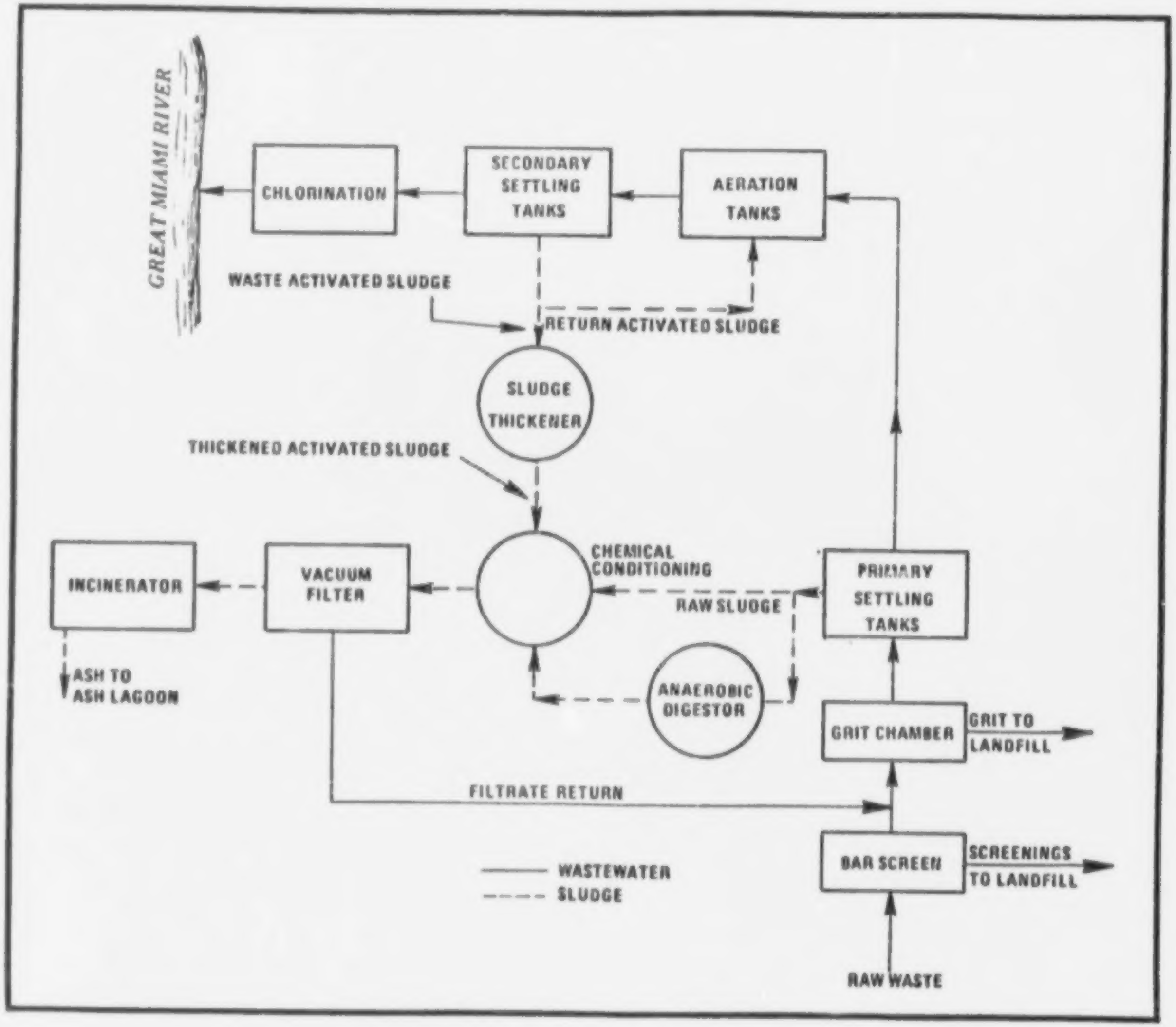

Figure B-4. Flow diagram for Middletown wastewater treatment plant.

tling tanks flows into aeration tanks, where an active bio-mass breaks down the organic matter. Any excess bio-mass is settled out into secondary clarifiers, and the effluent from the secondary clarifier is chlorinated and discharged into the Great Miami River.

Solids Handling

Daily production is 103 wet tons (94 metric tons) of raw sludge at 6.9 percent solids, and 413 wet tons (375 metric tons) of waste activated sludge at 1 percent solids.

Anaerobic Digestion

Two digestor tanks with a total capacity of 1.4 million gallons (5,320 m^3) are provided. The raw sludge is pumped to the digestors, where detention time is 57 days. The digestors produce approximately 53,600 cubic feet (1,518 m^3) of gas per day; the gas is used in plant operation.

Since the capacity of the digestor is not enough for all the raw sludge currently produced, some of the raw sludge is bypassed for chemical conditioning.

Gravity Thickening

Two gravity thickeners are operated to thicken the waste activated sludge from 1 percent solids to 4.4 percent solids.

Chemical Conditioning

The thickened waste activated sludge and the anaerobically digested sludge are chemically conditioned. Daily use of conditioning agents totals 5,000 pounds (2,270 kg) of lime and 695 gallons (2.63 m^3) of ferric chloride at 10 percent concentration.

Vacuum Filtration

Three vacuum filters are provided, two having a filter cloth area of 500 square feet (46.5 m^2) and one having an area of 250 square feet (23.2 m^2). The smaller one is a standby unit. The filters are loaded at 2.68 pounds per square foot per hour (13.1 $kg/m^2/hr$). The design loading rate is 3.5 pounds per square foot per hour (17.1 $kg/m^2/hr$). Approximately 60 wet tons (54 metric tons) of filter cake at 26 percent solids is produced per day.

Incineration

Two multi-hearth incinerators are provided; one serves as a standby. The incinerator is loaded at about 60 tons wet (54 metric tons) per day and generates 6.5 tons (5.9 metric tons) of ash per day. Maximum capacity of each incinerator is 90 tons (82 metric tons) per day.

The ash is disposed of in two adjacent lagoons, each of 3000 cubic yard (2,300 m^3) capacity; one is used while the other is being cleaned. Normally, one lagoon fills in about 4 months.

B.5 FRANKLIN AREA WASTEWATER TREATMENT PLANT (Ref. B-5)

The Franklin Area Wastewater Treatment Plant, operated by the Miami Conservancy District, is located on Route 73, Franklin, Ohio, on a 230-acre (568 hectare) tract on a flood plain of the Great Miami River. The plant serves about 35 percent residential and 65 percent commercial-industrial users. Industries are mainly paper and metal fabricating.

Except for save-alls in the paper industry, none of the industries provides pretreatment. The Miami Conservancy District holds the policy that industries should not be burdened with pretreating their wastes, since waste treatment is not their primary function.

The wastewater treatment plant is fully integrated with a solid waste plant located across the street. A distinctive feature of this environmental control complex is that both the plants are oriented towards resource recovery and reuse of paper fibers and glass.

General Facility Description

Current flow of influent	9 mgd (34,200 m^3/d)
Design flow	23 mgd (87,400 m^3/d)
Current population served	11,000
Design population (year 1985)	18,000

Liquid Treatment (Figure B-5)

Separate primary treatments are provided for municipal and industrial influents. The screened raw wastewaters are pumped in parallel into separate distribution chambers ahead of the treatment units. From the distribution chambers, the influent flows through two separate grit chambers into pre-aeration tanks and then into two separate primary clarifiers.

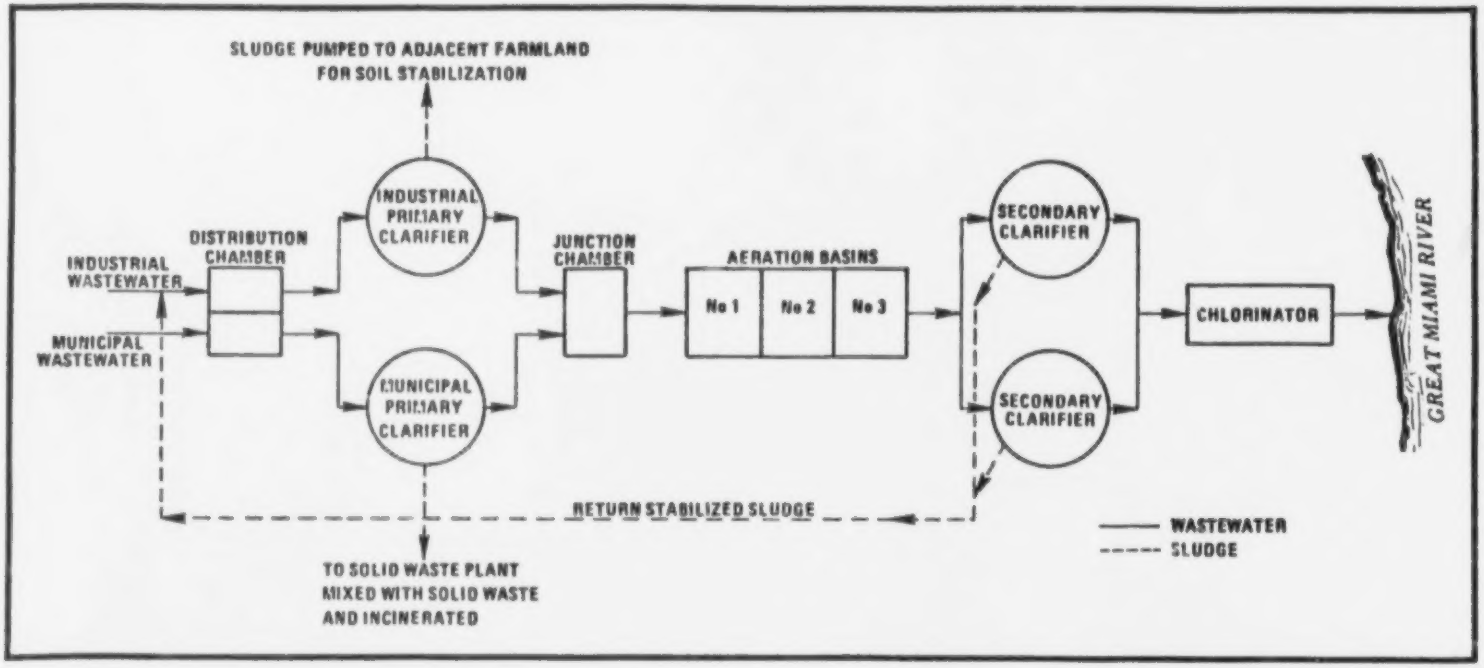

Figure B-5. Flow diagram for Franklin wastewater treatment plant.

From the primary clarifiers the municipal and industrial effluents are mixed and treated together. Three earthen aeration basins are utilized for operation of a modified activated sludge step-aeration process. Final secondary clarifiers are provided as part of the activated sludge process secondary treatment facilities. Secondary clarified effluent discharges over V-notch weirs into a chlorinator prior to discharge to the Great Miami River.

Solids Handling

Secondary clarified sludge is returned and mixed with the raw industrial wastewater at the head end of the plant. The plant does not have, nor do they plan to have, a separate sludge storage facility.

Production is estimated at about 16.6 wet tons (15.1 metric tons) per day of primary municipal sludge at 6 percent solids. This sludge is pumped to the solid waste plant, where it is mixed with household trash and garbage and incinerated. The fluid-bed incinerator has a capacity of 150 tons (135 metric tons) per day.

Daily production of primary industrial sludge ranges from 57 wet tons (51.9 metric tons) per day to about 686 wet tons (623 metric tons) per day, with a mean of 229 tons (208 metric tons) per day. Since 1972, this sludge has been pumped about 1000 feet (305 meters) to adjacent farmland owned by the Miami Conservancy District. Thus far they have applied about 1,500 wet tons (1,350 metric tons) of sludge per acre on 10 acres (4 hectares) of land. Tomatoes, lima beans, carrots, and cabbage have been grown successfully, but corn does not grow well, possibly because of nitrogen deficiency.

A total of 230 acres (93 hectares) of land is available for land application of sludge. Groundwater has been continuously monitored for 3 years from 14 test wells, placed at various locations within the plant premises. No adverse environmental impacts have been detected.

B.6 MUDDY CREEK WASTEWATER TREATMENT PLANT (Ref. B-6)

The Muddy Creek Plant located at 6125 River Road in Cincinnati, is operated by the Metropolitan Sewer District of Greater Cincinnati. The plant serves 99 percent residential community with 1 percent industrial and commercial. The small group of industries that discharge wastewater into the plant consists of trucking, transportation, and petroleum storage.

General Facility Description

Current flow of influent	8.3 mgd (3,154 m^3/d)
Design flow rate	15.0 mgd (57,000 m^3/d)
Current population served	63,000
Design population (year 2000)	118,000

Liquid Treatment (Figure B-6)

Incoming raw wastewater from the sewer system enters a flood control chamber before it enters the pump building. The pump building houses a screening device and a wet well. The wastewater is then pumped into detritus tanks where sand, cinders, and coarse grit are removed. From the detritus tanks the influent flows through a comminutor to pre-aeration tanks, which are used primarily to keep the wastewater fresh but can also be used for the mixing of chemicals to remove phosphorous, as required. Most of the suspended solids are then settled out in the primary settling tanks. Biological treatment is provided by the activated sludge treatment process. Finally, the effluent is chlorinated prior to discharging into the Ohio River.

Solids Handling

The plant produces 117 wet tons (106 metric tons) of raw sludge at 6 percent solids per day and generates 30 wet tons (27 metric tons) of waste activated sludge at 1 percent solids per day. Therefore, a total of 147 tons (133 metric tons) of combined wet sludge at 5 percent solids is pumped daily to two sludge holding tanks. The total volume of the two holding tanks is 83,800 cubic feet (2,346 m^3).

Sludge Concentration Tank

One sludge concentration unit of the dissolved air flotation type is provided, but it was not operating at the time of the visit. All waste activated sludge and some of the raw sludge can be concentrated to an average of 6 percent solids with loading rate of 0.95 pounds per square foot per hour (4.65 $kg/m^2/hr$).

Thermal Conditioning

The thermal conditioning unit also was not operating, and the combined wet sludge was being hauled to Mill Creek WTP for incineration and

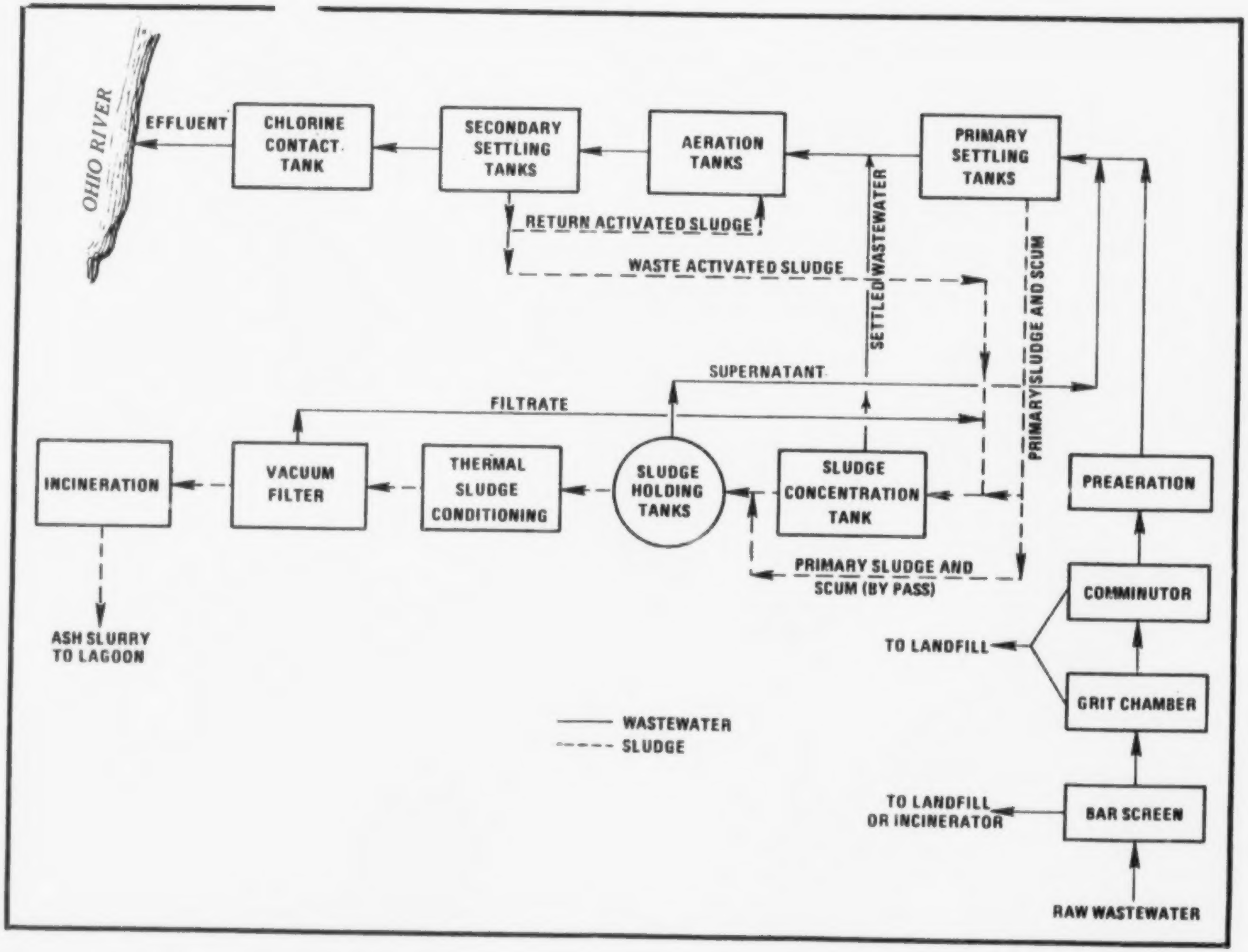

Figure B-6. Flow diagram for Muddy Creek wastewater treatment plant.

ultimate disposal. When the unit is in operation, the sludge is conditioned with high-pressure steam at 275 psig (19.0×10^6 N/m^2) and temperature 370F (188C). The sludge is pumped from the storage tanks to sludge grinders, which chop large solids into particles 0.25 inch (0.64 cm) or smaller. High-pressure sludge pumps follow the grinders in the flow pattern and provide a smooth flow at 275 psig (19.0×10^6 N/m^2) pressure to a two-stage heat exchanger, in which hot sludge from the reactors heats circulating water. This heated water then flows to the second section of the heat exchanger, where cold incoming sludge from the high-pressure pumps is heated by the water. The reactor is an insulated pressure vessel designed to hold the sludge for approximately 45 minutes at a flow rate of 4,000 gallons (15 m^3) per hour.

Vacuum Filtration

Two vacuum filters of 250 square feet (23.2 m^2) each are provided. Normally one is in operation and the other is a standby unit. The filters are loaded at 5 pounds per square foot per hour (24.5 kg/m^2/hr). Solids content of the filter cake is between 35 and 40 percent.

Incineration

The incinerator is rated to handle 6,000 pounds per hour (2,724 kg/hr) of sludge cake (35 to 40% solids) with a resulting ash generation of 920 pounds per hour (418 kg/hr). Ash is normally disposed of in an adjacent ash lagoon having a 20-year life at design operating rates. The incinerator however, was not operating at the time of the visit.

B.7 HAMILTON WASTEWATER TREATMENT PLANT (Ref. B-7)

The city of Hamilton operates this plant, which is located on River Road in Hamilton, Ohio. Some of the industries the plant services include plating, chemicals, and paper. Only the paper industry has a pretreatment step.

One large paper industry, Champion Paper, has its own wastewater treatment plant across the river from the Hamilton plant. It is proposed that in about 2 years, the City of Hamilton will take over the operation of the Champion wastewater plant. At that time, Champion will provide primary treatment for its waste and pump the effluent across the river for secondary treatment at the City of Hamilton Plant.

The city has also proposed to construct an Energy Resource Recovery Center, about 3 miles (5 km) north of the city. If the plan is approved, the city hopes to incinerate a mixture of garbage and sludge to produce steam to run the City's Power Plant.

General Facility Description

Current flow of influent	7 mgd (26,600 m^3/d)
Design flow	12 mgd (45,600 m^3/d)
Current population served	70,000
Design population	75,000

Liquid Treatment (Figure B-7)

The wastewater enters the plant through a 60-inch-diameter interceptor. To prevent clogging of the pumps, coarse material in the raw wastewater is continuously and automatically cut and screened by a comminuting-type bar screen without removing the screenings from the flow. Wastewater is then pumped from the wet well to two aerated type grit chambers. The grit is removed from the hopper and disposed of in a landfill. Raw waste from the grit chambers flows to the primary settling tanks.

A maximum of 6 mgd (22,800 m^3/d) of settled wastewater enters three aeration tanks. Effluent from the aeration tanks settles in the secondary settling tanks before it is chlorinated and discharged to the Great Miami River. If the flow exceeds 6 mgd (22,800 m^3/d) (capacity of aeration tanks), the excess is bypassed into a chlorine contact chamber and discharged to the river. When the expansion is complete this situation will not occur.

Solids Handling

Current daily production of raw sludge is 254 wet tons (231 metric tons) at 3.5 percent solids.

Vacuum Filtration

The raw sludge is chemically conditioned prior to filtration with about 2000 pounds (900 kg) per day of ferric chloride and 200 pounds (91 kg) per day of liquid caustic.

Two vacuum filters, each of 250 square foot (23 m^2) area, are used alternately each week so that one is always on standby. The filters are loaded at about 5 pounds per square foot per hour (24.5 kg/m^2/hr) and produce about 50 wet tons (45 metric tons) per day of filter cake at 20 percent solids.

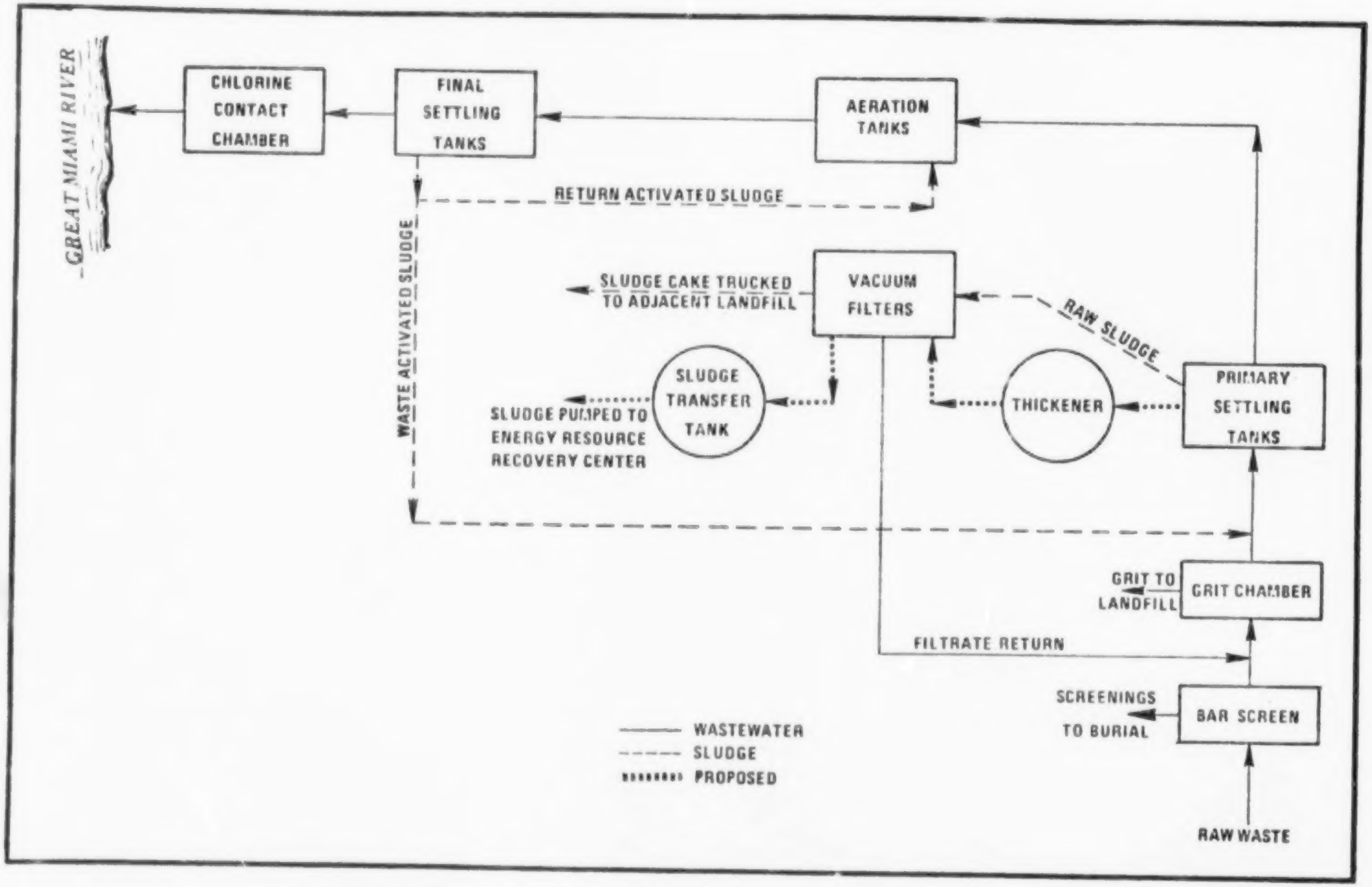

Figure B-7. Flow diagram for Hamilton wastewater treatment plant.

Sludge Transportation

The filter cake is transported by truck to an adjacent landfill about 0.5 mile (0.8 km) from the treatment plant. Approximately 12 round trips are made each day.

Sanitary Landfill

There are 17 acres (7 hectares) of land available for sanitary landfilling. In the landfill, the filter cake is mixed with construction site debris. It is covered daily, except Saturdays and Sundays, with fill in the proportion of 3:1.

The landfill has a life of 7-1/2 years if it is used for the filter cake from the wastewater treatment plant together with the lime sludge from the water treatment plant. Additional land that can be acquired for landfill in the future amounts to 48 acres (19 hectares).

Proposed Sludge Handling Facility

The city has proposed to build an Energy Resource Recovery Center about 3 miles (5 km) north of the city. If the plans are approved, the raw sludge will be thickened prior to vacuum filtration. The two digestors that are currently not in use will be converted to thickening units. Thickened sludge will then be vacuum filtered and stored in a sludge transfer tank. The sludge will then be pumped to the Center, where it will be incinerated together with the city's garbage and solid wastes. The resultant heat will be used to produce steam to run the City's Power plant.

B.8 SYCAMORE CREEK WASTEWATER TREATMENT PLANT (Ref. B-8)

The Sycamore Wastewater Treatment Plant, operated by the MSD of Greater Cincinnati, is located on Remington Road in a residential area in the Northeast section of Hamilton County, Ohio. About 90 percent of the service area is residential, 5 percent is commercial, and 5 percent is industrial.

General Facility Description

Current flow of influent	3.5 mgd (13,300 m^3/d)
Design flow	5.0 mgd (19,000 m^3/d)
Current population served	30,000
Design population	50,000

Liquid Treatment (Figure B-8)

Raw wastewater enters a grit chamber, where the coarse grit is removed. From the grit chamber it flows through a mechanically cleaned bar screen into primary settling tanks. The settled wastewater then enters an aeration tank, where most of the oxygen-demanding organic matter is broken down by microorganisms. The effluent is then settled out in secondary settling tanks, postchlorinated, and finally discharged into Sycamore Creek. During heavy rains, when the plant capacity is exceeded, some of the influent is bypassed into a storm water holding tank and then discharged into Sycamore Creek directly without treatment.

Solids Handling

The plant produces 58 wet tons (53 metric tons) per day of raw sludge at 4 percent solids and 67 wet tons (61 metric tons) per day of waste activated sludge at 0.5 percent solids.

Anaerobic Digestors

The raw sludge is pumped to a two-stage anaerobic digestor at a rate of 14,200 gallons (54 m^3) per day. Gas produced from the digestors is used to heat the digestors, and the excess is burned off.

Gravity Thickener

One gravity thickener of 960 square foot (89 m^2) area is provided. The waste activated sludge is thickened and then pumped to the anaerobic digestors.

Approximately 5,900 gallons (22.4 m^3) of thickened and digested sludge is trucked daily to Mill Creek WTP, where it is dewatered and incinerated.

B.9 OXFORD WASTEWATER TREATMENT PLANT (Ref. B-9)

The Oxford Wastewater Treatment Plant is operated by the City of Oxford in Butler County, Ohio, and is located on McKee Avenue. The plant discharges its effluent into the Four Mile Creek. Oxford is mostly a residential area with some commercial but no industrial activities.

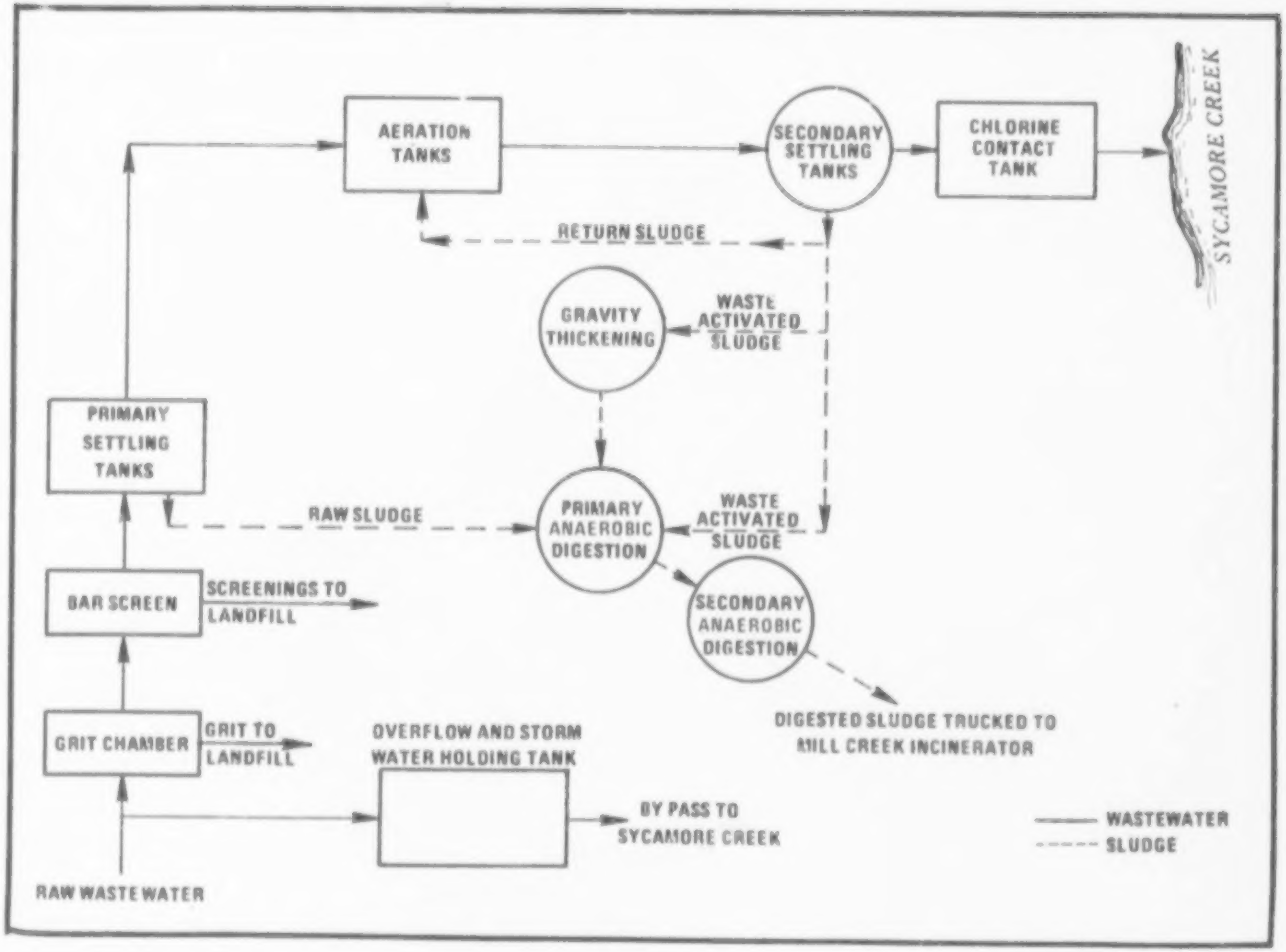

Figure B-8. Flow diagram for Sycamore wastewater treatment plant.

General Facility Description

Current flow of influent	2.64 mgd (10,000 m^3/d)
Design flow	9.00 mgd (34,200 m^3/d)
Current population served	21,700
Design population	30,000

Liquid Treatment (Figure B-9)

The influent flows through bar screens and is pumped to a vaculator, where grit and scum are separated. Grit is pumped to a grit classifier and collected in a dumpster truck to be hauled to a landfill. From the vaculators, the liquid waste flows to a decant tank, where the skimmings are separated.

Suspended solids are removed in two circular primary settling tanks. Biological treatment is provided by use of high-rate trickling filters. Some of the effluent from the trickling filters is recirculated to the primary settling tanks, and the rest is allowed to settle out into two secondary settling tanks. The clarified effluent is disinfected in a chlorine contact tank and discharged into Four Mile Creek.

Solids Handling

Total production of sludge (raw plus return secondary) each day is 37 wet tons (34 metric tons) at 6 percent solids.

Anaerobic Digestor

Two anaerobic digestor tanks are operated in a two-stage sequence. The digestor tanks are designed for a loading rate of 0.12 pounds per cubic foot per day (1.93 $kg/m^3/d$) and a detention time of 40 days. Approximately 15,000 cubic feet (425 m^3) of gas is produced per day. Most of the gas is used to heat the digestors and the rest is wasted, since there is no gas storage facility.

A private contractor hauls 2.05 wet tons (1.9 metric tons) per day of anaerobically digested sludge at 5 percent solids to farmland in the area.

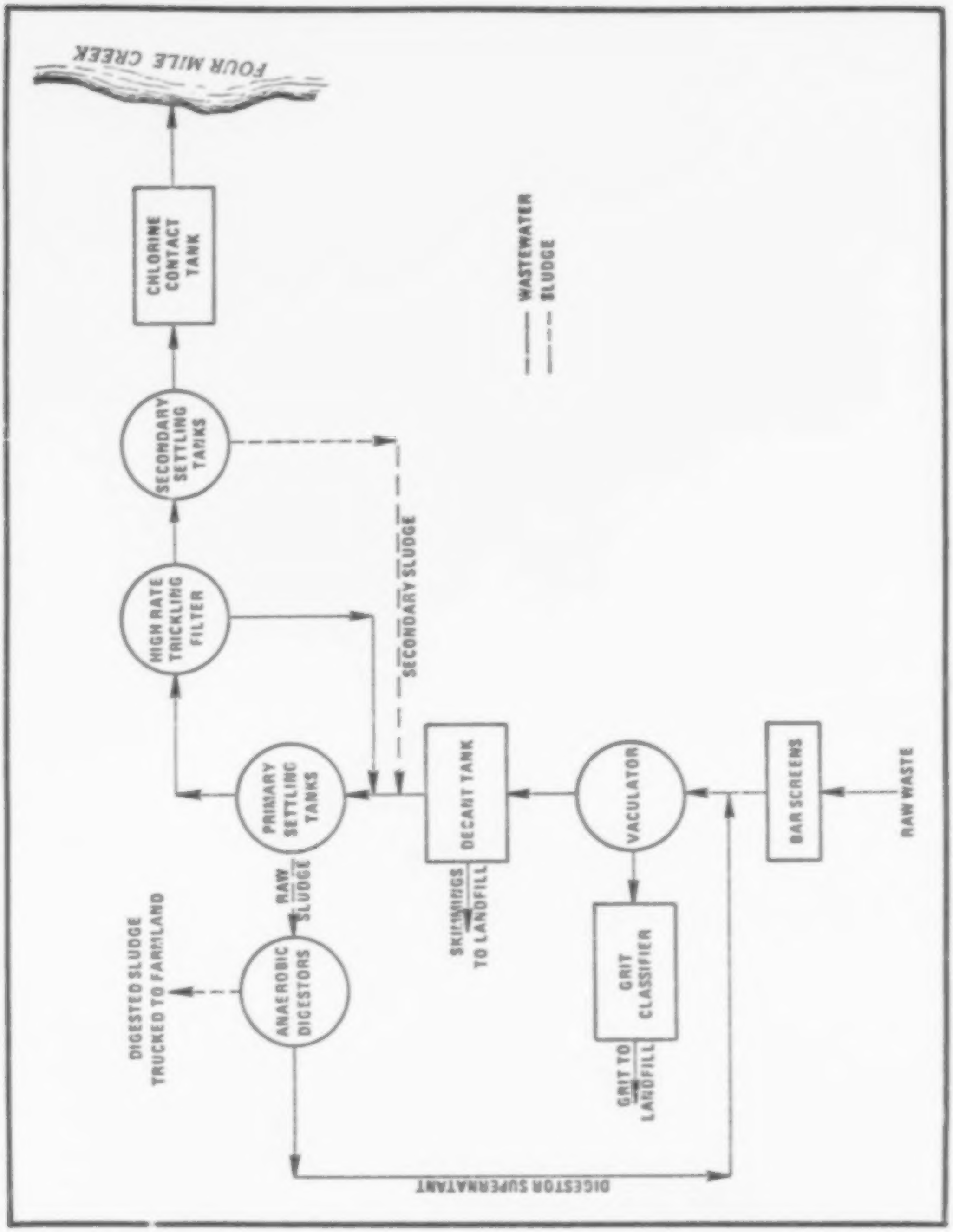

Figure B-9. Flow diagram for Oxford wastewater treatment plant.

B.10 LAWRENCEBURG WASTEWATER TREATMENT PLANT (Ref. B-10)

The South Dearborn Regional Sewer District operates the plant, which is located on Third Street in Lawrenceburg, Indiana.

The District operates two separate plants, designated as Plants No. 1 and No. 2, which are located about a half mile (0.8 km) apart. Plant No. 1 handles strictly industrial waste, together with the waste sludge from Plant No. 2. Plant No. 2 handles about 55 percent domestic and 45 percent industrial treated effluent from Plant No. 1. The major industries in the district are two distilleries and a plating operation.

General Facility Description

Plant No. 1

Current flow of influent	1.4 mgd (5,320 m^3/d)
Design flow	1.5 mgd (5,700 m^3/d)

Plant No. 2

Current flow of influent	2.5 mgd (9,500 m^3/d)
Design flow	3.5 mgd (13,300 m^3/d)
Current population served	15,000
Design population	32,000

Liquid Treatment (Figure B-10, Plates A and B)

Plant No. 1

Industrial wastewater from the City of Lawrenceburg, together with the waste sludge from Plant No. 2 enters an influent wet well and a bar screen. The raw waste is then pumped into a cooling tower, since the waste from the distillaries must be cooled from 140F (60C) to 95F (35C) to facilitate further treatment. From the cooling tower, the waste flows through a grit collector and a comminutor to the anaerobic digestors. The supernatant from the digestors is degasified prior to final clarification. Clarified effluent is then pumped to Plant No. 2 for further treatment.

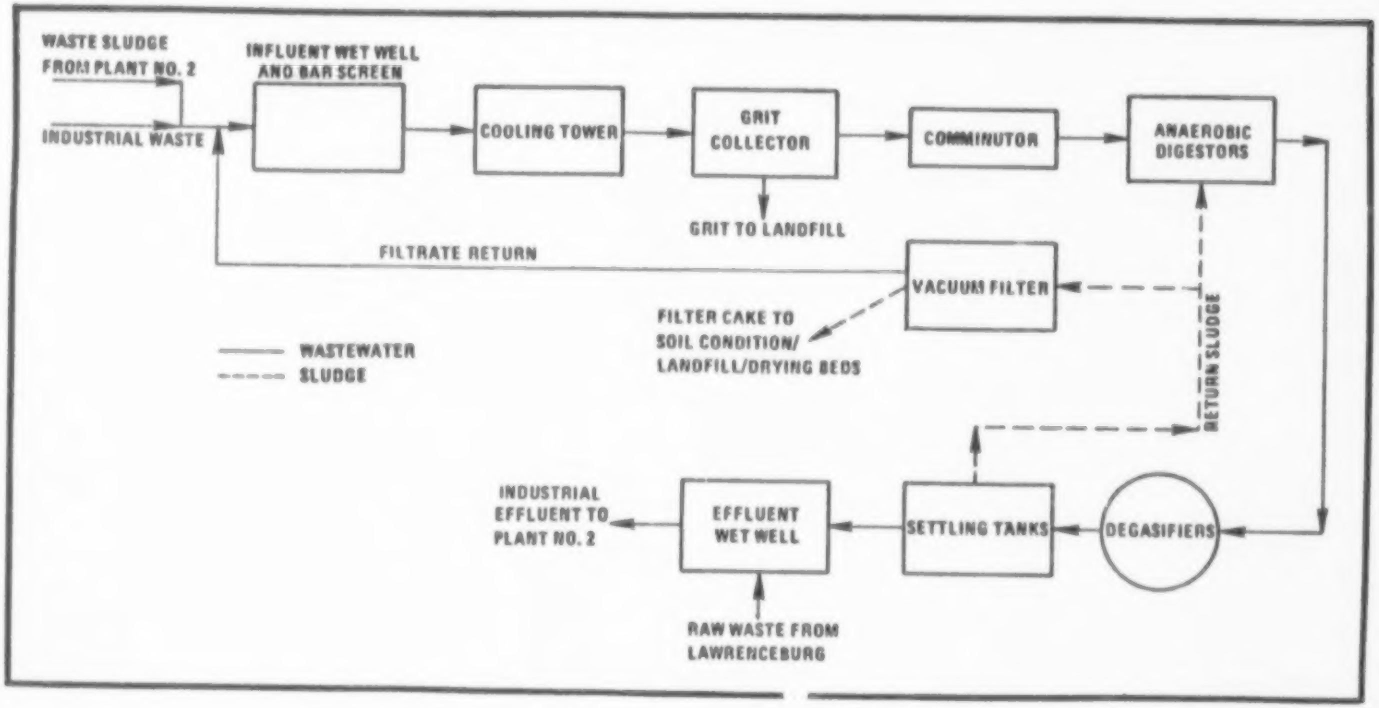

Figure B-10. Flow diagram for Lawrenceburg wastewater treatment plant No. 1, (Plate A).

Plant No. 2

Raw domestic wastewater is mixed with the effluent from Plant No. 1. The mixture flows through a comminutor, bar screen, and grit chamber. Activated sludge type of treatment is provided in the aeration tanks. The remaining suspended solids are allowed to settle out in the final settling tanks; the effluent is chlorinated and discharged to the Ohio River.

Solids Handling

Daily input to Plant No. 1 is 950 wet tons (853 metric tons) of waste sludge from plant No. 2 at 2 percent solids and 333 wet tons (303 metric tons) of industrial sludge at 0.3 percent solids.

Anaerobic Digestors

Two digestor tanks, each of 360,000 gallon (1,368 m^3) capacity are provided, but are not used as conventional anaerobic digestion units. Sludge enters the digestion tanks, which are not heated, and any gas that escapes is burned off.

No stratification occurs in the tanks. After a detention time of 10 to 12 hours, the liquid fraction and the solids undergo degasification. Finally the solids are settled out in the settling tanks.

A portion of the settled sludge undergoes vacuum filtration and the rest is returned to the anaerobic digestors. Lime and ferric chloride are the conditioning agents for vacuum filtration.

Vacuum Filtration

One vacuum filter of 262 square foot (24.3 m^2) area is provided. The filter is loaded at 3.2 pounds per square foot per hour (15.7 $kg/m^2/hr$) and produces 2.1 wet tons (1.9 metric tons) per day of filter cake at 25 percent solids.

The filtered sludge cake is usually hauled by a local farmer in his own truck for land spreading. If the farmer is not able to haul the sludge, it is either stored in dumpster trucks or put on sand drying beds located adjacent to Plant No. 1.

Approximately 975 wet tons (885 metric tons) per day of combined waste secondary plus industrial sludge at approximately 2.0 percent solids is sent from Plant No. 1 to the secondary clarifier in Plant No. 2. Periodically, this sludge is wasted to the Ohio River.

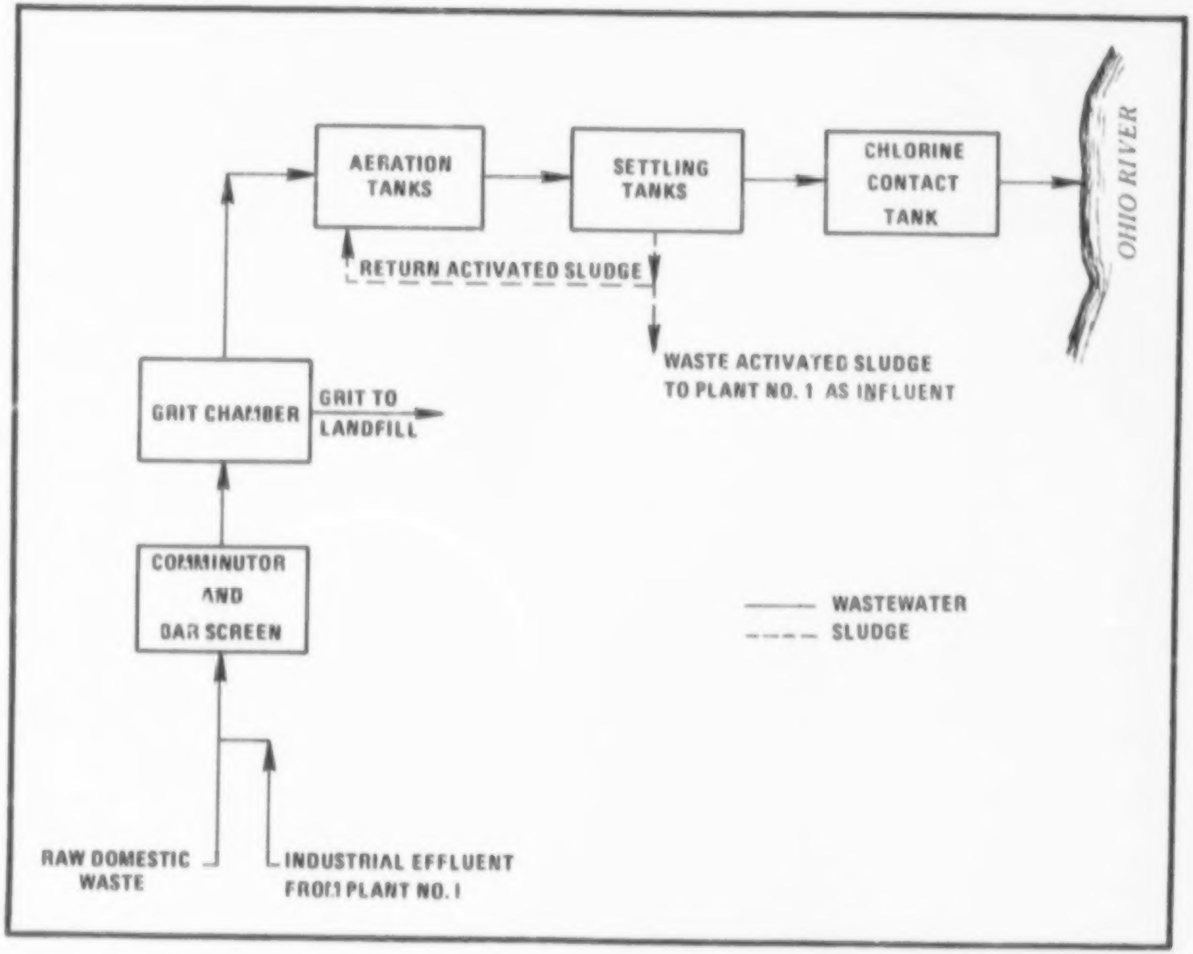

Figure B-10. Flow diagram for Lawrenceburg wastewater treatment plant No. 2, (Plate B).

B.11 BETHEL WASTEWATER TREATMENT PLANT (Ref. B-11)

This plant is located on West Street in Bethel, Ohio, and is operated by the Clermont County Sewer district. The plant serves a mostly residential and commercial community in the village of Bethel. No known industrial waste sources are connected to the treatment works.

General Facility Description

Current flow of influent	0.47 mgd (1,786 m^3/d)
Design flow	0.52 mgd (1,976 m^3/d)
Current population served	2400
Design population	2700

Liquid Treatment (Figure B-11)

Raw wastewater flows through a manually cleaned bar screen into the primary clarifier. Clarified effluent then flows to a standard trickling filter. The effluent from the trickling filter settles out in the final settling tank before discharge to Town Run Creek.

Solids Handling

Raw sludge is pumped to a 79,206 gallon (300 m^3) unheated anaerobic digestor. About 18 loads per month of digested sludge are hauled away in a 2,300 gallon (8.7 m^3) tank truck. The sludge is hauled to different sites, depending on what is available.

The plant generates about 5.7 wet tons (5.2 metric tons) of anaerobically digested sludge daily. A solids concentration of 4.0 percent is assumed, since plant data are not available. Drying beds of 5,280 square feet (490 m^2) are available at the plant site but are not used because citizens have complained of odors.

B.12 NEW RICHMOND WASTEWATER TREATMENT PLANT (Ref. B-12)

The Village of New Richmond in Clermont County operates this plant, which is located on Front Street and Route 52. The plant serves a mostly residential and commercial community. One wool mill is the only industry that discharges effluent to the plant. The mill has some pretreatment capabilities and contributes about 3 percent of the total flow into the plant.

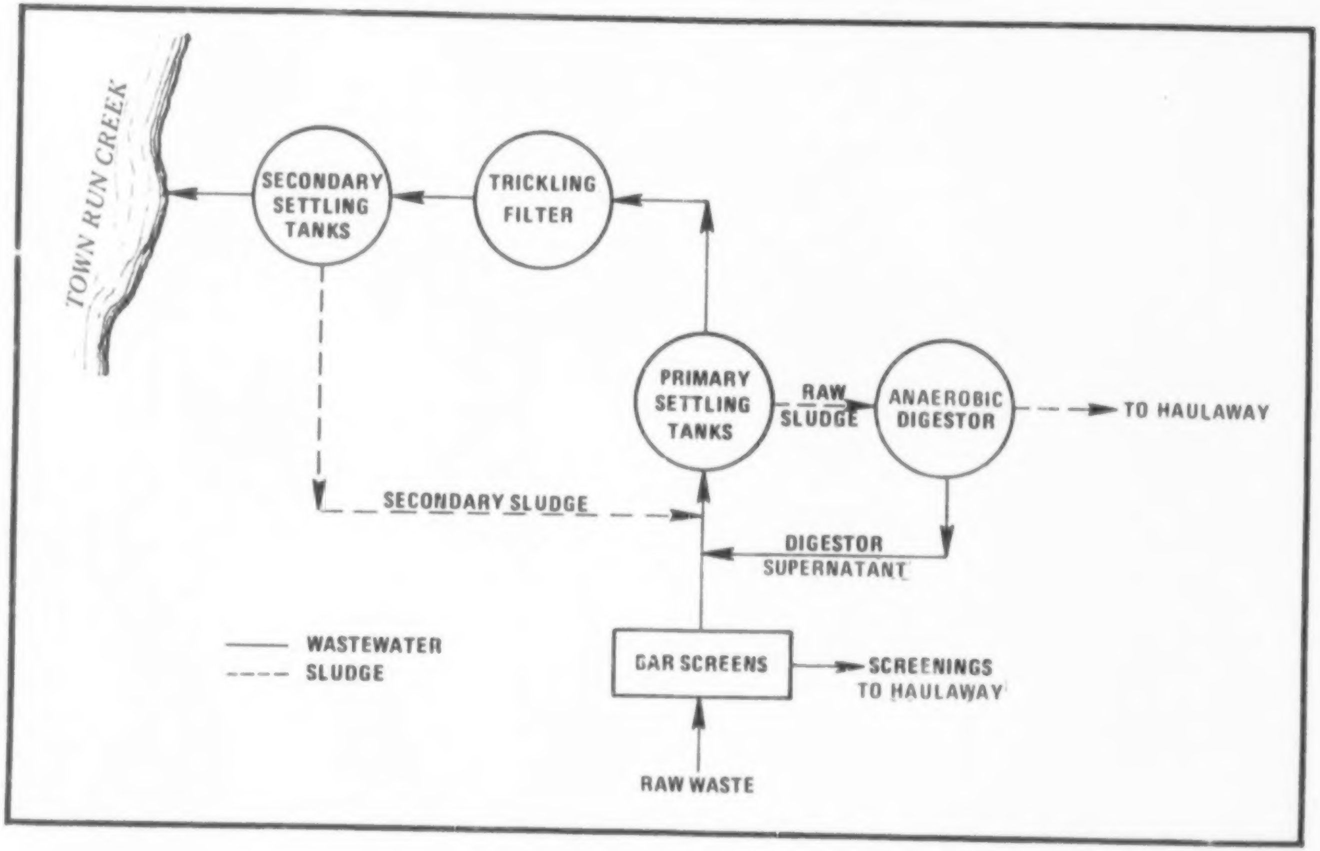

Figure B-11. Flow diagram for Bethel wastewater treatment plant.

General Facility Description

Current flow of influent	0.10 mgd (380 m^3/d)
Design flow	0.40 mgd (1,520 m^3/d)
Current population served	1725
Design population	2500

Liquid Treatment (Figure B-12)

The facility is a small "package" unit. Influent normally enters the plant through a comminutor and flows into a wet well. In an emergency or breakdown, the influent can be bypassed through the bar screens. From the wet well, the influent is pumped into a contact stabilization unit, which consists of an aeration zone, a clarifier, a re-aeration zone, and an aerobic digestor. The clarified effluent is chlorinated before being discharged into the Ohio River.

Solids Handling

About 0.82 wet ton (0.75 metric ton) per day of waste sludge at 1 percent solids is fed to the aerobic digestor.

Aerobic Digestor

The digestor has a capacity of 92,000 gallons (350 m^3). Periodically, sludge from the digestor is wasted to the sludge holding tank.

Sludge Holding Tank

The sludge holding tank has a capacity of 250,000 gallons (950 m^3). During the winter months, the sludge is held in the tanks and not hauled away.

Sand Drying Beds

Six drying beds with a total area of 1,200 square feet (111 m^2) are provided. During warm weather, sludge is drawn from the holding tanks and spread on the drying beds to a depth of 6 inches (15 cm). After about 3 weeks, the dried sludge is taken off the sandbeds and stockpiled in an adjacent area.

Local residents and at least two farmers haul the sludge from the stockpiles on an as-needed basis. The farmers use the sludge as a soil conditioner for corn and tobacco crops.

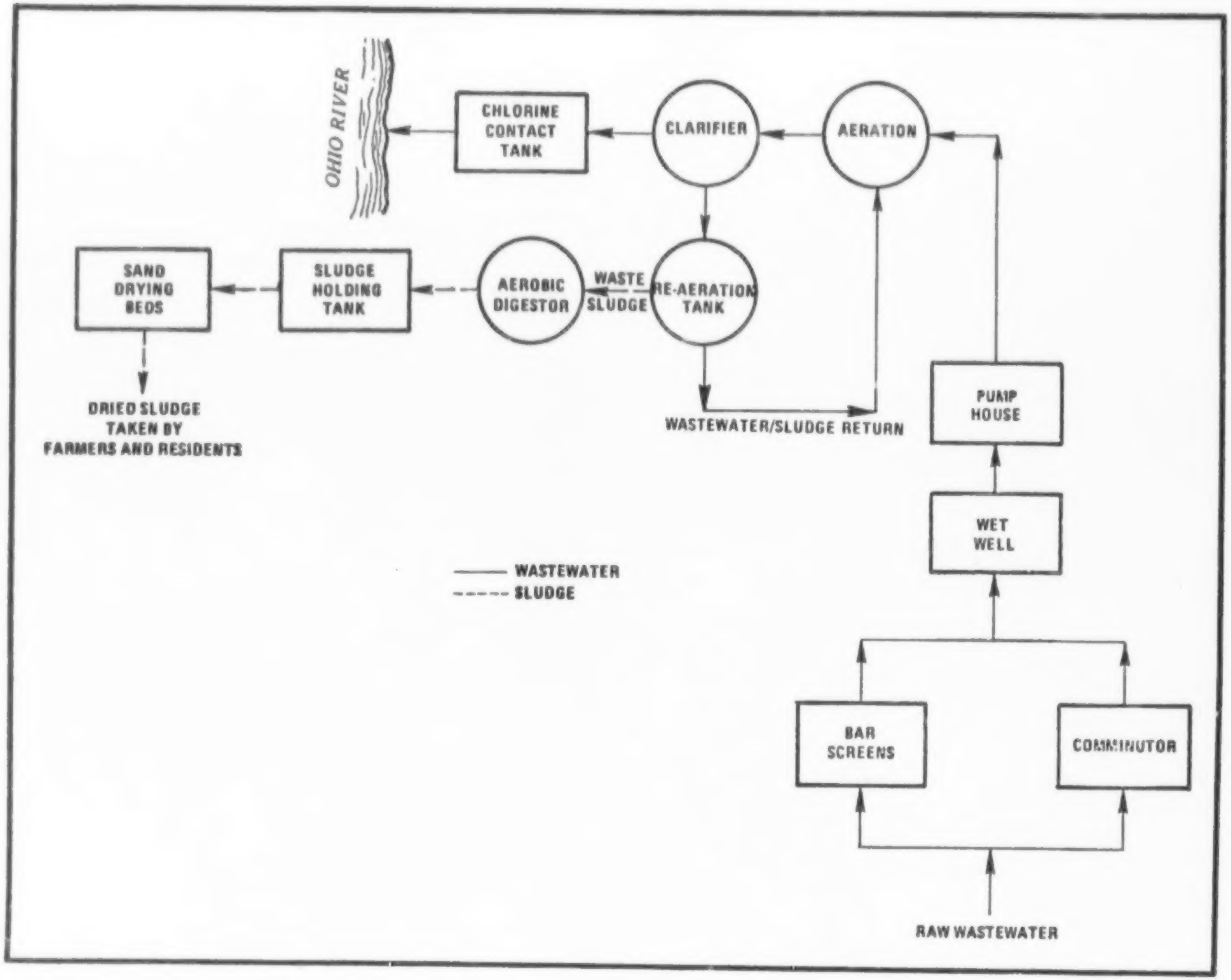

Figure B-12. Flow diagram for New Richmond wastewater treatment plant.

B.13 FELICITY WASTEWATER TREATMENT PLANT (Ref. B-13)

Felicity wastewater treatment plant, located on Prather Road in Felicity, Ohio, is operated by the Clermont County Sanitary District. The plant serves the residential and commercial community in Felicity. No industries operate in the area.

General Facility Description

Current flow of influent	0.081 mgd (307 m^3/d)
Design flow	0.20 mgd (760 m^3/d)
Current population served	650
Design population	1500

Liquid Treatment (Figure B-13)

Flow enters through a comminutor into an aeration basin, which provides secondary treatment by extended aeration. The treated effluent is clarified, chlorinated, and discharged to Bear Creek.

Solids Handling

Approximately 1 wet ton (0.91 metric ton) per day of waste activated sludge at 1 percent solids is hauled by local truckers to nearby farmland. This practice has been used for the past 2 years.

B.14 MAYFLOWER WASTEWATER TREATMENT PLANT (Ref. B-14)

This package plant, operated by the MSD of Greater Cincinnati, is located on Overdale Drive in Hamilton County and serves about 200 new homes. It serves no commercial or industrial institutions.

General Facility Description

Current flow of influent	0.035 mgd (133 m^3/d)
Design flow	0.080 mgd (304 m^3/d)
Current population served	600
Design population	600

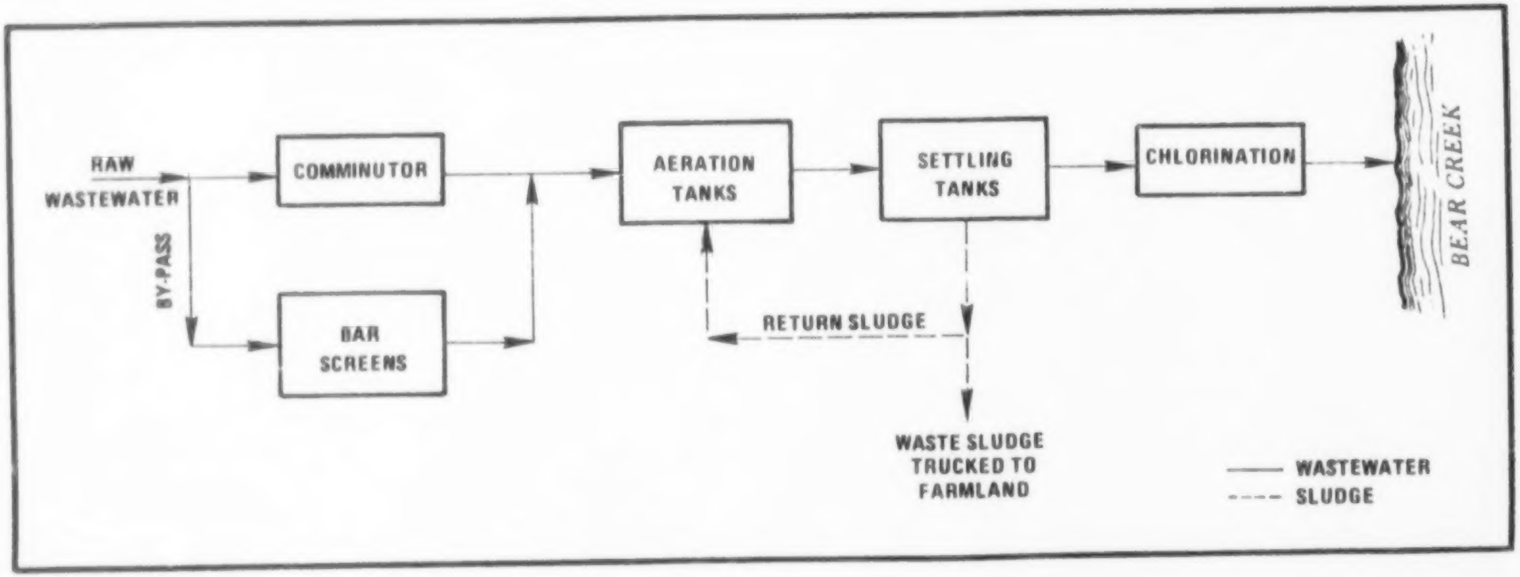

Figure B-13. Flow diagram for Felicity wastewater treatment plant.

Liquid Treatment (Figure B-14)

The plant provides secondary treatment by the contact stabilization process. It can provide tertiary treatment, but the rapid sand filter was out of operation at the time of inspection. The effluent is chlorinated before being discharged into the Banklick Creek.

Solids Handling

Theoretically 11.4 wet tons (10.4 metric tons) per day of waste activated sludge at 1 percent solids is fed to the aerobic digestor. Capacity of the digestor is 18,300 gallons (69 m^3), sufficient for 2 to 3 days. Every two weeks one 1600-gallon (6 m^3) tank truck hauls 1200 gallons (4.6 m^3) of sludge to the Mill Creek Wastewater Treatment Plant, where it is dewatered and incinerated.

B.15 SYSTECH WASTEWATER TREATMENT PLANT (Ref. B-15)

The Systech Waste Treatment Plant, owned and operated by Systems Technology Corporation of Dayton, is located on Route 73, in Franklin, Ohio. This plant operates with the Miami Conservancy District Regional Wastewater Treatment Plant and the City of Franklin Solid Waste Plant to form the Franklin Environmental Complex, one of the most comprehensive waste treatment facilities in the area.

The Systech Plant is basically a service organization for pretreatment of liquid industrial waste before discharge into the environment, as required by the Federal Water Pollution Control Act amendments of 1972. Most of the small industries of the area were faced with the prospect of building and operating their own treatment plants. Since this was economically unfeasible for some of the marginal industries, the services offered by Systech appeared to be an attractive alternative. The plant serves a radius of about 150 miles (240 km). Some of the major industries served by the plant are fabricated metal products, petroleum and allied products, rubber and plastics, primary metal industries, chemicals and by-products, food products, paper and printing products, textile mill products, and machinery and tooling.

Liquid Treatment

Liquid industrial wastes are shipped to the plant in volumes ranging from 55 gallon (0.208 m^3) drums to tankers. The plant is equipped with receiving and holding tanks for noncombustible wastes. The liquid wastes are analyzed in the Systech laboratories. Depending upon the type and the constituents of the wastes, one or more of the following methods of treatment is applied: oxidation-reduction, acidulation, neutralization, chemical detoxification, thermal destruction, solvent or petroleum recovery.

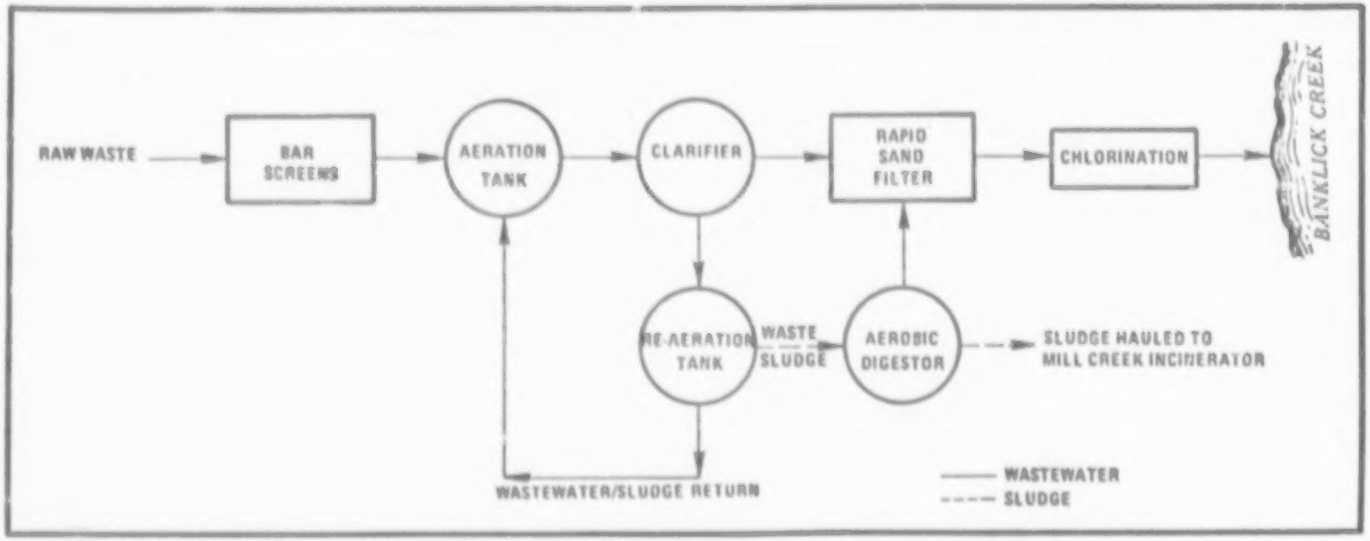

Figure B-14. Flow diagram for Mayflower wastewater treatment plant.

The treated waste, which is of an acceptable quality for treatment in a conventional municipal treatment plant, is then pumped about 1 mile (1.6 km) to the Miami Conservancy District's wastewater treatment plant. If it contains much inert material, the waste is pumped to the primary industrial clarifier; otherwise it is pumped to the primary municipal clarifier.

B.16 DRY CREEK WASTEWATER TREATMENT PLANT (Proposed; Ref. B-16)

The Dry Creek Wastewater Treatment facilities, located on High Water Road, near Constance, Kentucky, will be operated by the Sanitation District No. 1, Campbell and Kenton Counties, Kentucky. About 15 percent of the total flow in the design year is expected to be from industries. One of the major industrial waste load contributors will be the Weidemann Brewery; the others are several small industrial foundations and the Greater Cincinnati Airport. The District has proposed that industries be required to provide and maintain sampling and gauging stations on their wastewater discharges for the purpose of determining loads and flows. This information will be a basis for determination of user charge.

General Facility Description

Design flow	30 mgd (114,00 m^3/d)
Design population served (year 2000)	270,000

Liquid Treatment (Figure B-16)

Wastewater from the Lakeview and Dry Creek area and from the Bromley Pump Station will be screened and will then flow into five grit-removal tanks. From the grit tanks, the wastewater will flow to primary settling tanks. Effluent from the primary tanks will flow to aeration tanks. The wastewater will then be clarified, chlorinated, and discharged into Dry Creek.

Solids Handling

Total daily sludge production in the design year will consist of 410 wet tons (372 metric tons) of raw sludge at 5 percent solids and 3,049 wet tons (2,768 metric tons) of waste activated sludge at 1 percent solids.

Secondary Sludge Thickeners

The waste activated sludge will be concentrated from 1 percent solids to 5 percent solids in dissolved air flotation thickeners. The thickeners

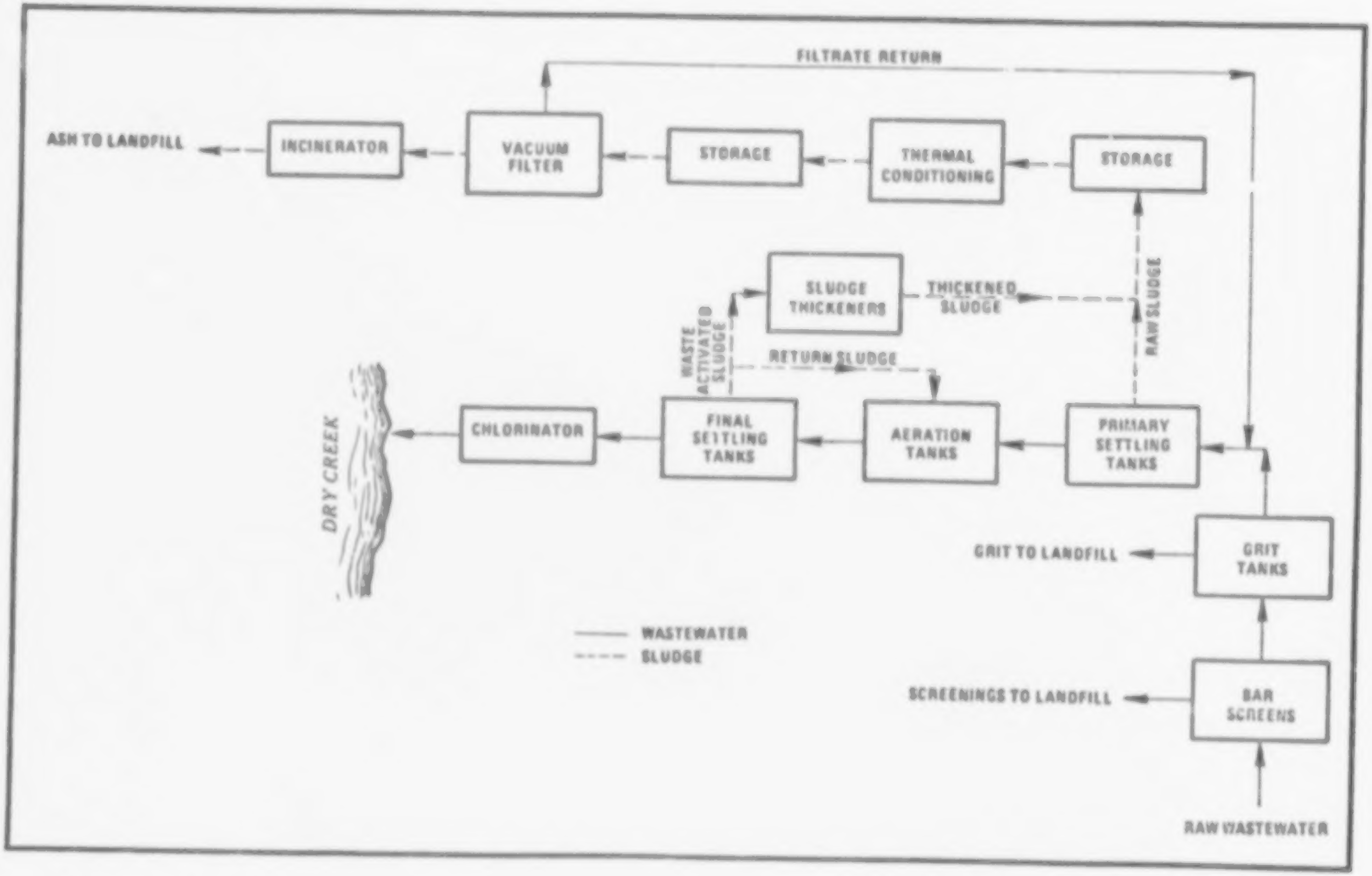

Figure B-16. Flow diagram for Dry Creek wastewater treatment plant.

will be loaded at a rate of 0.5 pound of suspended solids per square foot per hour (2.5 kg/m^2/hr). Based on this loading rate and a normal operation of 168 hours per week, four units with a total surface area of 5,240 square feet (487 m^2) will be required.

Sludge Storage

The raw sludge and the thickened waste activated sludge will be stored prior to thermal conditioning. Based on maximum storage requirements during wet weather, it is proposed that three tanks, each with a volume of 200,000 gallons (760 m^3), be provided.

Thermal Conditioning

The combined wet sludge will be thermally conditioned prior to vacuum filtration. At a production rate of 3,550 pounds per hour (1,612 kg/hr) of dry solids and a normal operating rate of slightly over 21 hours per day, daily production will be about 457 tons (415 metric tons) of thermally conditioned sludge at 8 percent solids. This thermally conditioned sludge will be stored in a 200,000- gallon (760 m^3) tank.

Vacuum Filtration

Three 400 square foot (37 m^2) filters are proposed. Normally two filters will be on line while the third is on standby. Yield from the vacuum filters will be 8 pounds per square foot per hour (39 kg/m^2/hr). Approximately 104 wet tons (94.6 metric tons) of filter cake at 35 percent solids will be produced each day.

Incineration

Two incinerators, each operating about 11 hours per week, are proposed. In case of emergency or breakdown of a unit, the other could be operated 22 hours per day. The incinerators will yield 14 tons (12.7 metric tons) of ash per day. At an ash density of 30 pounds per cubic foot (481 kg/m^3), approximately 35 cubic yards (27 m^3) of ash will be removed to a landfill each day.

B.17 LESOURDSVILLE REGIONAL WASTEWATER TREATMENT PLANT (Proposed; Ref. B-17)

When construction is completed in August 1977, the plant will be operated by Butler County; it is to be located on State Route 4 in LeSourdsville, Ohio. The total load that will be contributed by industries and the type of industries to be served are not known.

General Facility Description

Design flow	4 mgd (15,200 m^3/d)
Design population	40,000

Liquid Treatment (Figure B-17)

Raw influent will flow through a bar screen and a grit chamber into primary settling tanks. Biological treatment will be provided by trickling filters. Prior to final settling tanks, phosphate removal is provided. Tertiary filters will provide further removal of suspended solids. Finally the effluent will be chlorinated, aerated, and discharged into the Great Miami River.

Solids Handling

Total daily sludge production will be 25 wet tons (23 metric tons) at 4 percent solids, and 87 wet tons (79 metric tons) of secondary sludge at 2.5 percent solids.

Aerobic Digestors

The raw sludge and the secondary sludge will be pumped to two aerobic digestors, each with a capacity of 236,500 gallons (900 m^3). The combined detention time in the tanks will be 18 days. Approximately 79 wet tons (72 metric tons) of the digested sludge will be hauled away for disposal per day.

Sludge Conditioning and Concentration

It is proposed that if sludge conditioning is required, 10 to 15 pounds (4.5 to 6.8 kg) of polymers per ton (0.9 metric ton) of dry solids will be added.

One sludge concentration unit (stand-by) is proposed to handle 1,200 gallons per hour (4.6 m^3/hr) for production of a thickened sludge at a solids content of 15 to 18 percent. This material will be landfilled at a site about 6 miles (10 km) away.

B.18. CLEVES - NORTH BEND WASTEWATER TREATMENT PLANT (Proposed; Ref. B-18)

The Cleves - North Bend Wastewater Treatment Plant is the smallest of the proposed plants selected for case study. The plant will be located on Harbor Drive, Cleves, Ohio, and will be operated by the Village of

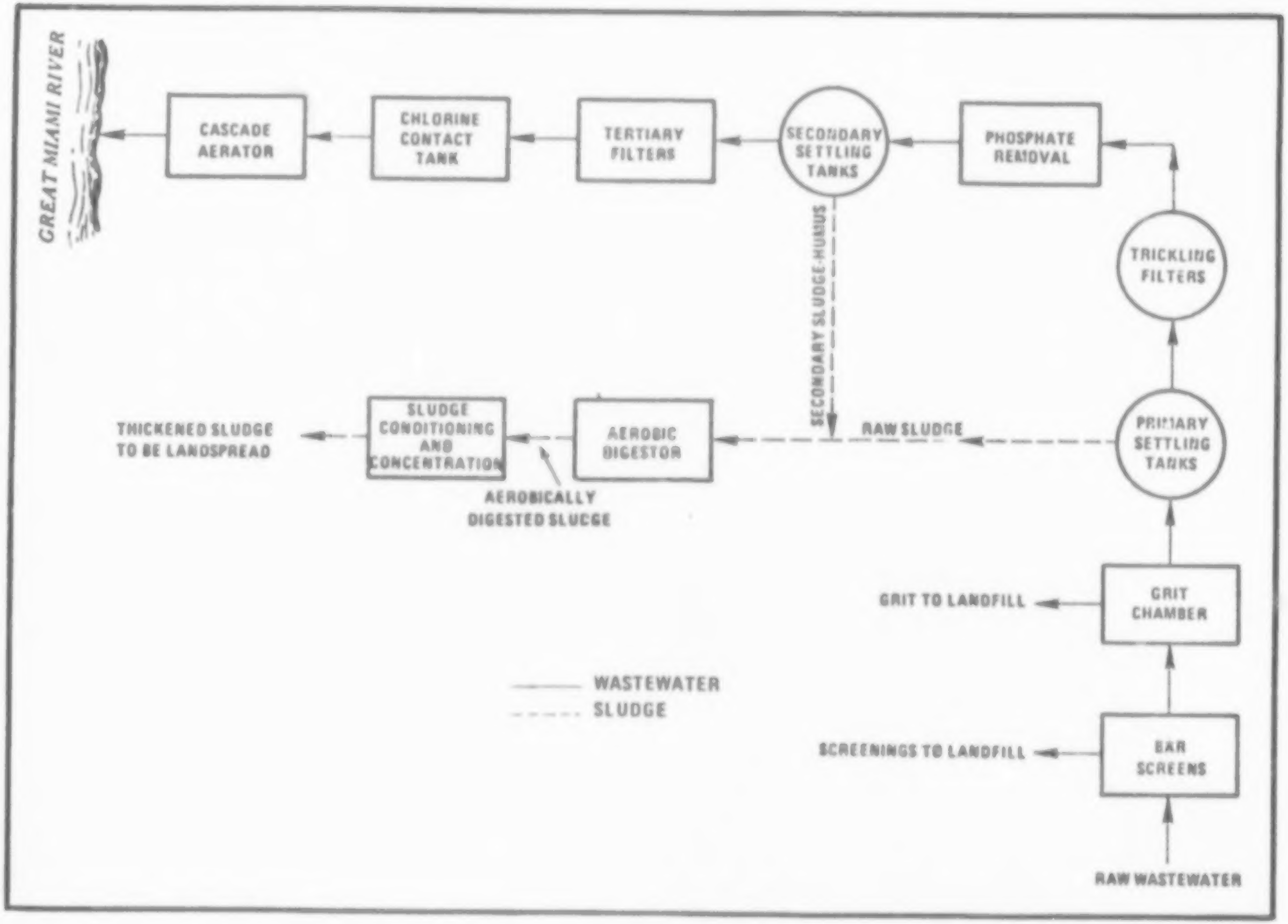

Figure B-17. Flow diagram for LeSourdsville regional wastewater treatment plant.

Cleves. It is scheduled to go into operation in 1978 and is designed to handle primarily residential wastewater.

General Facility Description

Design flow	0.5 mgd (1,900 m^3/d)
Design population (year 2000)	4,980

Liquid Treatment (Figure B-18)

Raw wastewater will enter an inlet structure for distribution to two primary clarifiers. Secondary treatment is provided by rotary biological contractors. The effluent is clarified prior to chlorination and then discharged into the Ohio River.

Solids Handling

About 20 wet tons (18 metric tons) of raw sludge at 4 percent solids will be produced each day. The secondary sludge is recycled to the inlet structure.

Aerobic Digestion

Raw sludge and return secondary sludge are pumped into an aerobic digestor. The digestor is loaded at 2 cubic feet (0.056 m^3) per capita.

Centrifugation

The aerobically digested sludge will be centrifuged in a horizontal unit loaded at 2,000 pounds (988 kgs) per hour to yield sludge with a solids content of 45 percent. The centrifuge will operate 7 hours per week to yield approximately 0.93 wet ton (0.84 metric tons) of dewatered sludge per day. Dewatered sludge will be disposed of in a landfill on site.

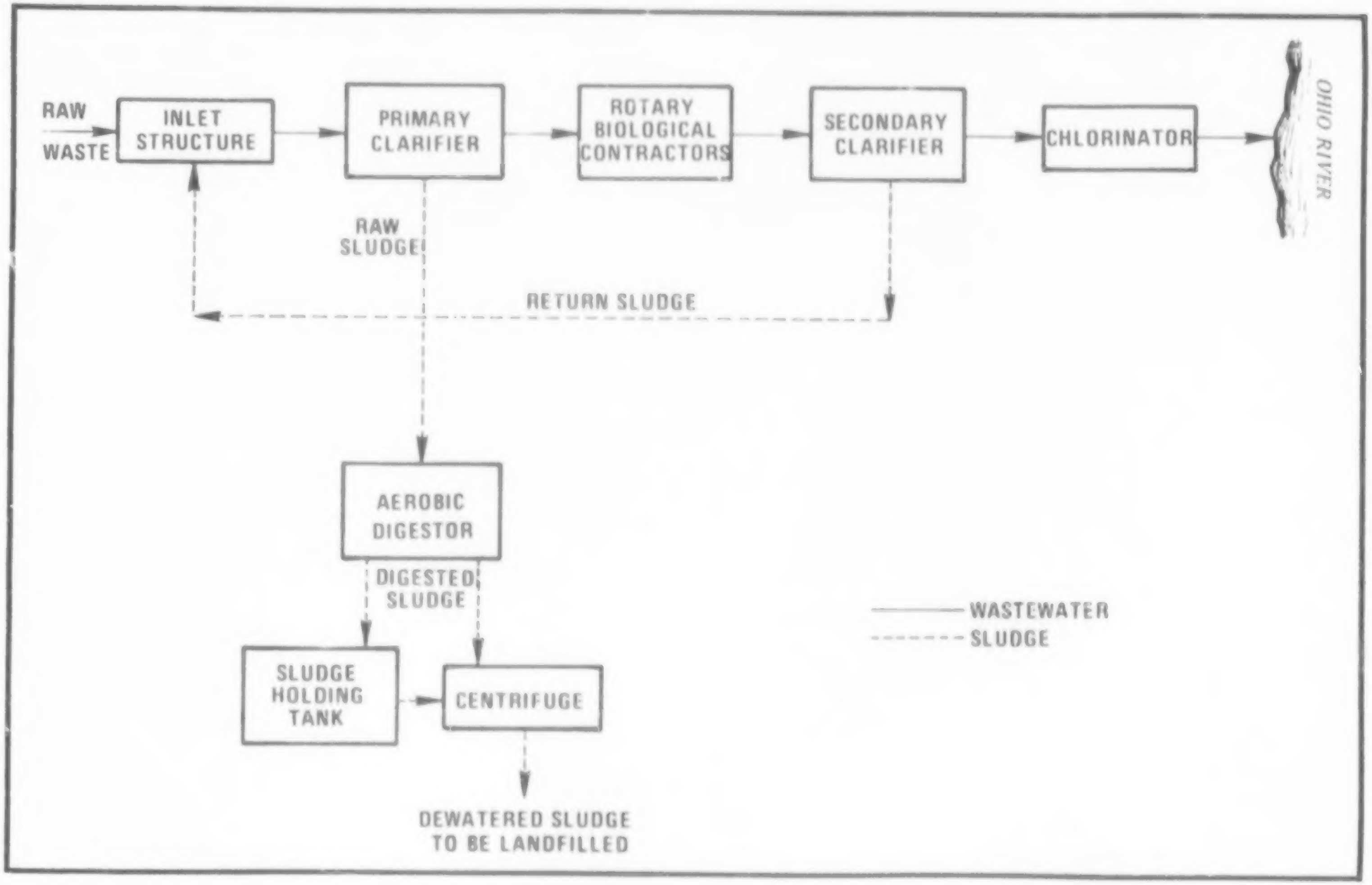

Figure B-18. Flow diagram for Cleves-North Bend wastewater treatment plant.

REFERENCES

B-1 Seymour, Gerry. The Metropolitan Sewer District of Greater Cincinnati, 1600 Gest Street, Cincinnati, Ohio.

B-2 Pritchard, Robert. The Metropolitan Sewer District of Greater Cincinnati, 1600 Gest Street, Cincinnati, Ohio.

B-3 Goebel, Robert. Sanitation District No. 1 of Campbell and Kenton Counties, Kentucky.

B-4 Keith, Harry. Middletown Wastewater Treatment Plant, 300 Oxford State Road, Middletown, Ohio.

B-5 Flower, Wesley. The Miami Conservancy District, 38 East Monument Avenue, Dayton, Ohio.

B-6 Weider, Charles. The Metropolitan Sewer District of Greater Cincinnati, 1600 Gest Street, Cincinnati, Ohio.

B-7 Harrel, Thomas. Hamilton Wastewater Treatment Plant, River Road, Hamilton, Ohio.

B-8 Ross, John. The Metropolitan Sewer District of Greater Cincinnati, 1600 Gest Street, Cincinnati, Ohio.

B-9 Pitman, Bruce. City of Oxford Wastewater Treatment Plant, Municipal Building, Oxford, Ohio.

B-10 Yorkanin, John. South Dearborn Regional Sewer District, Third and U.S. 50 West, Lawrenceburg, Indiana.

B-11 Wardroup, John. Clermont County Sewer District, 66 S. Riverside Drive, Batavia, Ohio.

B-12 Poynter, Robert. Village of New Richmond Wastewater Treatment Plant, Front Street and Route 52, East, New Richmond, Ohio.

B-13 Snider, Ray. Clermont County Sanitary District, 66 South Riverside Drive, Batavia, Ohio.

B-14 Seymour, Gerry. The Metropolitan Sewer District of Greater Cincinnati, 1600 Gest Street, Cincinnati, Ohio.

REFERENCES (continued)

B-15 Wittmann, Thomas. Systems Technology Corporation, 3131 Encrete Lane, Dayton, Ohio.

B-16 Supplement I, Dry Creek Wastewater Treatment Plant Sewerage System Improvement Design Report. Sanitation District No. 1, Campbell and Kenton Counties, Kentucky. (January 1972).

B-17 Hinchberger, James. Sanitary Engineering Department, Butler County, 720 Campbell Avenue, Hamilton, Ohio.

B-18 Stitt, David. M.M. Schirtzinger & Associates, Limited, 1550 Western Avenue, Chillicothe, Ohio.

APPENDIX C

NATIONAL AIR QUALITY STANDARDS

NATIONAL AMBIENT AIR QUALITY STANDARDS[a]

	Primary Standard		Secondary Standard	
	µg/m^3	ppm	µg/m^3	ppm
Sulfur oxides				
annual arithmetic mean	80	0.03		
24-hour concentration	365[b]	0.14[b]		
3-hour concentration			1300[b]	0.5[b]
Suspended Particulate matter -				
annual geometric mean	75		60	
24-hour concentration	260[b]		150[b]	
Carbon monoxide -				
8-hour concentration		9.0	Same as primary	
1-hour concentration		35.0		
Photochemical oxidants - 1-hour concentration	160[b]	0.08[b]	Same as primary	
Hydrocarbons (Corrected for methane)				
3-hour concentration (6-9am)	160[b]	0.24[b]	Same as primary	
Nitrogen oxides - annual arithmetic mean	100	0.05	Same as primary	

[a] 40 CFR 50; 36 FR 22384, November 25, 1971, EPA Regulations.

[b] Not to be exceeded more than once a year.

40 CFR, PART 60 - STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES

60.2 Definitions

(a) "Act" means the Clean Air Act (42 U.S.C. 1857 et seq., as amended by Public Law 91-604, 84 Stat. 1676).

...

(c) "Standard" means a standard of performance proposed or promulgated under this part.

(d) "Stationary source" means any building, structure, facility, or installation which emits or may emit any air pollutant.

...

(f) "Owner or operator" means any person who owns, leases, operates, controls, or supervises an affected facility or a stationary source of which an affected facility is a part.

(g) "Construction" means fabrication, erection, or installation of an affected facility.

...

(j) "Opacity" means the degree to which emissions reduce the transmission of light and obscure the view of an object in the background.

...

(v) "Particulate matter" means any finely divided solid or liquid material, other than combined water, as measured by Method 5 of Appendix A to this part or an equivalent or alternative method.

Subpart O - Standards of Performance for Sewage Treatment Plants

60.150 Applicability and designation of affected facility.

The affected facility to which the provisions of this subpart apply is each incinerator which burns the sludge produced by municipal sewage treatment facilities.

60.152 Standard for particulate matter.

(a) On and after the date on which the performance test required to be conducted by 60.8 is completed, no owner or operator of any sewage sludge incinerator subject to the provisions of this subpart shall discharge or cause the discharge into the atmosphere of:

(1) Particulate matter at a rate in excess of 0.65 g/kg dry sludge input (1.30 lb/ton dry sludge input).

(2) Any gases which exhibit 20-percent opacity or greater. Where the pressence of uncombined water is the only reason for failure to meet the requirements of this paragraph, such failure shall not be a violation of this section.

60.154 Test Methods and Procedures

...

(b) For Method 5, the sampling time for each run shall be at least 60 minutes and the sampling rate shall be at least 0.015 dscm/min (0.53 dscf/min), except that shorter sampling times, when necessitated by process variables or other factors, may be approved by the Administrator.

(c) ...

(3) Determine the quantity of dry sludge per unit sludge charged in terms of either R_{DV} or R_{DM}.

(i) If the volume of sludge charged is used:

$$S_D = (60 \times 10^{-3}) \frac{R_{DV} S_V}{T} \text{ (Metric Units)}$$

or

$$S_D = (8.021) \frac{R_{DV} S_V}{T} \text{ (English Units)}$$

where:

S_D = average dry sludge charging rate during the run, kg/hr (English units: lb/hr).

R_{DV} = average quantity of dry sludge per unit volume of sludge charged to the incinerator, mg/l (English units: lb/ft^3).

S_V = sludge charged to the incinerator during the run, m^3 (English units: gal).

T = duration of run, min (English units: min).

60×10^{-3} = metric units conversion factor, $l\text{-}kg\text{-}min/m^3\text{-}mg\text{-}hr$.

8.021 = English units conversion factor, $ft^3\text{-}min/gal\text{-}hr$.

(ii) If the mass of sludge charged is used:

$$S_D = (60) \frac{R_{DM} S_M}{T} \text{ (Metric or English Units)}$$

where:

S_D = average dry sludge charging rate during the run, kg/hr (English units: lb/hr).

R_{DM} = average ratio of quantity of dry sludge to quantity of sludge charged to the incinerator, mg/mg (English units: lb/lb).

S_M = sludge charged during the run, kg (English units: lb).

T = duration of run, min (Metric or English units).

60 = conversion factor, min/hr (Metric or English units).

(d) Particulate emission rate shall be determined by:

$$C_{aw} = C_s Q_s \text{ (Metric or English Units)}$$

where:

C_{aw} = particulate matter mass emissions, mg/hr (English units: lb/hr).

C_s = particulate matter concentration, mg/m^3 (English units: lb/dscf).

Q_s = volumetric stack gas flow rate, dscm/hr (English units: dscf/hr). Q_s and C_s shall be determined using Methods 2 and 5, respecitvely.

(e) Compliance with 60.152(a) shall be determined as follows:

$$C_{ds} = (10^{-3}) \frac{C_{aw}}{S_D} \text{ (Metric Units)}$$

or

$$C_{ds} = (2000) \frac{C_{aw}}{S_D} \text{ (English Units)}$$

where:

C_{ds} = particulate emission discharge, g/kg dry sludge (English units: lb/ton dry sludge).
10^{-3} = Metric conversion factor, g/mg.
2000 = English conversion factor, lb/ton.

(39 FR 9319, Mar. 8, 1974; 39 FR 13776, Apr. 17, 1974; 39 FR 15396, May 3, 1974)

OHIO AND HAMILTON COUNTY AMBIENT AIR QUALITY STANDARDS FOR SUSPENDED PARTICULATES, SULFUR DIOXIDE, CARBON MONOXIDE, PHOTOCHEMICAL OXIDANTS, NON-METHANE HYDROCARBONS, AND NITROGEN DIOXIDE

Contaminants	Primary Standard			Secondary Standard		
	Concentration		Average interval	Concentration		Average interval
	$\mu g/m^3$	ppm by vol.		$\mu g/m^3$	ppm by vol.	
Suspended Particulates	75	---	AGM	60	---	AGM
	260	---	24 hr	150	---	24 hr
Sulfur-Dioxide	80	0.03	AAM	60	0.02	AAM
	360	0.14	24 hr	260	0.10	24 hr
						3 hr
Carbon-Monoxide	10,000	9.0	8 hr	10,000	9.0	8 hr
	40,000	35.0	1 hr	40,000	35.0	1 hr
Photo-Chemical Oxidant	160	0.08	1 hr	160	0.08	1 hr
Hydrocarbons (nonmethane)	160	0.24	3 hr a.m.	160	0.24	3 hr a.m.
Nitrogen-Dioxide	100	0.05	AAM	100	0.05	AAM

Note:
1. All values other than annual values are maximum concentrations not to be exceeded more than once per year.
2. PPM values are approximate only.
3. All concentrations relate to air at standard conditions of 25°C temperature and 760 millimeters of mercury pressure.
4. $\mu g/m^3$ - micrograms per cubic meter.
5. AGM - Annual geometric mean.
6. AAM - Annual arithmetic mean.
7. Sulfur dioxide standards in Ohio are in the process of being revised.

APPENDIX D

SANITARY LANDFILLS IN THE O-K-I AREA

County	Name	Location	Estimated remaining capacity[a] (tons)	County	Name	Location	Estimated remaining capacity[a] (tons)
1. Butler	Oscar Schlichter Co.	2601 Hamilton-Cleves Rd., Hamilton, Ohio	b	15. Hamilton	Village of Harrison	200 Harrison Rd. Harrison, Ohio	2,989
2. Butler	City of Oxford	Collins Run Rd. Oxford, Ohio	38,435	16. Hamilton	Loveland Landfill	100 E. Loveland Loveland, Ohio	40,996
3. Butler	Champion International Corporation	Hamilton-Cleves Rd. Hamilton, Ohio	438,000	17. Warren	Franklin Solid Waste Disposal	Farm Ave., Franklin, Ohio	b
4. Butler	Butler County Landfill	Woodsdale Rd. Trenton, Ohio	b	18. Warren	Stubbs Mills Landfill	Morrow Millgrove Rd., Morrow, Ohio	b
5. Butler	Fairfield Industrial Development	2841 Bobmeyers Rd. Fairfield, Ohio	64,057	19. Warren	Lebanon Landfill	Turtlecreek-Union Rd., Lebanon, Ohio	b
6. Clermont	Clermont Environmental Reclamation, Inc.	Aber Rd. Batavia, Ohio	b	20. Campbell	City of Newport Landfill	Route 9 Licking Pike, Kentucky	b
7. Dearborn	City of Lawrenceburg Landfill	West Center St. Lawrenceburg, Ind.	48,000	21. Campbell	City of Fort Thomas Landfill	Route 8 North of Silver Grove, Ky.	b
8. Dearborn	Rumpke Landfill Disposal	Husman Rd.; South of U.S. 50, Ind.	51,100	22. Kenton	Bavarian Trucking Company Landfill	Off Route 17 South of Independence, Ky.	b
9. Hamilton	Environmental Land Development Assoc.	Este Avenue, Cincinnati, Ohio	5,400,000	23. Boone	N. Kentucky Sanitarian Co.	McCoy Rd., Walton, Ky.	b
10. Hamilton	Rumpke Landfill Disposal	10795 Huges Rd. Cincinnati, Ohio	1,500,000				
11. Hamilton	BFI Waste Systems	Bond Rd, Cincinnati, Ohio	b				
12. Hamilton	Anderson Township Waste Collection	8311 Broadwell Rd. Cincinnati, Ohio	96,000				
13. Hamilton	City of Wyoming	800 Oak St Cincinnati, Ohio	9,608				
14. Hamilton	Village of Amberly Village	7149 Ridge Ave. Cincinnati, Ohio	b				

[a] Estimated remaining capacity was based on PEDCo surveys.

[b] Indicates disclosure of information refused or information not available.